THE PHILOSOPHY OF MUSIC.

BEING THE SUBSTANCE OF

A COURSE OF LECTURES

DELIVERED AT THE ROYAL INSTITUTION OF GREAT BRITAIN, IN FEBRUARY AND MARCH 1877.

BY

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ONE OF THE EXAMINERS IN MUSIC TO THE UNIVERSITY OF LONDON,
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THIRD EDITION, REVISED.

"Cunning in Musick and the Mathematics."
Taming of the Shrew.

LONDON:
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1891.

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THE

ENGLISH AND FOREIGN

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VOLUME XI.

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TO

WILLIAM SPOTTISWOODE, ESQ.,

M.A., D.C.L., LL.D.,

President of the Royal Society,

Corresponding Member of the French Academy of Sciences,

&c., &c., &c.

This Work

IS RESPECTFULLY DEDICATED,

IN ACKNOWLEDGMENT OF THE INTEREST

HE HAS ALWAYS TAKEN IN

THE PHILOSOPHICAL STUDY OF MUSIC.

PREFACE.

A SHORT time ago I was invited by Mr. Spottiswoode, then Honorary Secretary of the Royal Institution of Great Britain, to deliver there a course of lectures on the Theory of Music, as illustrated by the late researches of Helmholtz. I accepted the invitation with much pleasure; for I knew that the class of readers who could study these researches in their elaborate original form must be comparatively limited, and I felt that any explanations which would tend to make their great value and novelty better known and appreciated could not fail to be useful. The lectures were, I have reason to think, favourably received; and, as a general wish was expressed that they should be published, I now venture to offer for wider circulation the substance of the matter they contained.

I have endeavoured to simplify the subject as much as possible, divesting it of scientific difficulties; and I hope I may have succeeded in making it easily intelligible to all who are practically interested in the art.

It is now customary for the Universities granting musical degrees to make the qualifications for them

include theoretical as well as practical knowledge. I have had occasion to see the want of an elementary work on the former branch of study, and I trust the present volume may be of some use in that character. It cannot, of course, supply the place of the more comprehensive scientific treatises, but it may possibly serve as a convenient introduction to them.

W. P.

ATHENÆUM CLUB, LONDON, S.W.
May 1879.

PREFACE TO THE SECOND EDITION.

In this edition some amendments and additions have been introduced, and some changes have been made in the mode of speaking of the æsthetics of the art. This subject, or at least the most important part of it, is now becoming, under the name of Musical Psychology, a special science, so elaborate and difficult that it would be out of place to undertake, in a general technical work of this kind, any discussions connected with it.

I have therefore thought it right to express clearly that in the matter of æsthetics the scope of this treatise goes no farther than is necessary to explain the nature and origin of the ordinary forms and rules of musical structure.

While this edition has been passing through the press an important emendation has been pointed out, by a new historian, in regard to the Greek modes. It is mentioned in Note G.

I am pleased that the book has been found useful to candidates for University degrees.

W. P.

September 1887.

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THE PHILOSOPHY OF MUSIC.

CHAPTER I.

INTRODUCTION.

As this work is intended to treat of a branch of musical knowledge at present but little studied, it will be desirable to explain, somewhat fully, at the outset, what is meant by its title.

Music is peculiar among the fine arts, in that it requires special and very elaborate provisions for its presentation to the world. The painter and the sculptor have no sooner put the finishing touches to their works than they are at once in a state to be understood and appreciated. The poet and the author require but a printing press to render fully intelligible the ideas they have to convey. But the labours of the musical composer are, when he has completed them, only a mass of useless hieroglyphics until he can get them interpreted and made known by the process we call *performance*.

This condition has created a definite branch of the musical art for its due fulfilment. The performance of music has become, in the present day, a most comprehensive thing. It not only requires the manufacture of musical instruments of complicated and scientific con-

struction, but it also demands, in order to execute music effectively and properly, an amount of skill and excellence in the performers which can only be acquired by years of hard practice and study.

It is to the performance of music that by far the greatest share of attention is directed. Whenever music becomes a matter of public interest, as in concerts and operas, performance is the principal attraction; nearly all the eminent musicians whom the public know, they know only as performers; and the great mass of musical teaching and learning that goes on in private has performance in view, and nothing more.

This is all very well, and it is an excellent thing that the pleasure of music can be, and is, so widely distributed. But it must be remembered that there is something antecedent to the performance of music, that is, its *composition.* It is to be feared that the great majority of performers, both amateur and professional, think and care but little about this; they are content to take music as they find it, without troubling themselves as to how it has been made. They are much to blame; for though they may never wish to become composers, a knowledge of the structure of music is of the greatest advantage, not only in guiding its performance, but in increasing generally the enjoyment it is capable of affording.

Now when a student wishes to go beyond the practical performance of music, and to learn something of composition, he is said to enter upon what is called "Theory." The expression "Theory of Music" is a very common one, and, in strictness, may have a wide meaning; but it is much narrowed in its ordinary acceptation, and is understood by different classes of people in different ways.

The first and most elementary theoretical instruction usually given is in what is called "Thorough Bass" or

"Harmony." This consists of some general notions and rules about the nature and arrangements of chords, conveyed often in a form so complicated and difficult as to be very unattractive and unsatisfactory to the learner; and yet this is all that the great majority of students ever get to know about musical theory.

But we may go a step further. Suppose a student has some ambition to become a composer, and wishes to know how to write music creditably. He must then, in addition to the thorough bass or harmony course, study many other things, such as counterpoint, form, the art of instrumentation, and so on. This knowledge, which is very difficult to obtain, is learnt partly from the tuition of accomplished professors and partly from books; but chiefly by the assiduous and careful study of the works of the best composers. It then constitutes what is ordinarily considered "theory" in its highest development, as it comprises all the theoretical training available in the usual course of musical instruction.

No doubt such knowledge, when well acquired, is calculated to answer its purpose, and is sufficient to satisfy the wants of the would-be composer in a practical point of view. But it is doubtful how far the word "theory" is justly applicable to the kind of knowledge in question, which is, after all, essentially practical, formed entirely on observation and imitation of what has been done before, with very little reference to the reason why. The student has acquired the conviction that he must do so and so, because he finds Bach, Handel, and Mozart have done so and so; but his theoretical insight goes no further. What he has learnt is not really the Theory of Music, but the Art of Composition. It is very customary to call this "Science," and there is no objection to the term, provided it be understood to mean *practical* science, implying simply the knowledge how to do an important and difficult thing in the best and most approved way.

But there is a kind of knowledge which extends

much beyond this. We may easily suppose that a musical student, of an inquiring mind, might wish to go more to the root of the matter. Having made himself thoroughly acquainted with the practical structure of music, he might not unreasonably wish to find out on what sort of theoretical basis this structure was founded. He would inquire what light could be thrown on it by the phenomena and laws of sound; whether these would be sufficient to explain and justify all the varied musical forms and rules; and if not, what other *raisons d'être* could be offered for them. In short, he would desire to be satisfied as to how music had grown up to its modern state of advancement, and why it had taken its complex modern design.

The student might possibly be told that such knowledge was unnecessary for him; he might be reminded that the greatest musical composers that ever lived had known nothing of acoustics or of fundamental philosophical principles; that such knowledge was more fit for mathematicians than musicians, and that he had better ignore it altogether.

It is no doubt difficult to show any immediate bearing of this kind of knowledge on practical music; it is unquestionable that the highest proficiency, both in composition and performance, may exist without it, and it would be a mistake, in the author's opinion, to claim for these theoretical investigations a practical value which is negatived by the natural common sense of musicians.[1]

The philosophy of music, like many other high branches of knowledge, claims attention rather on intellectual

[1] For this reason I am reluctantly compelled to dissent from the following sentence in the preface of the able translator of Helmholtz's work: "The object of the present Treatise is . . . to prove that musicians can not only not get on much better without Acoustics than with, but that they really cannot get on without Acoustics at all." I cannot find that any such claim is put forward in the work itself, the modesty of which, in its absence of pretension on practical grounds, is most remarkable.

than on utilitarian grounds. The argument that would restrict a man's acquirements to those things that he needs for earning his livelihood, is worthy only of a barbarous age. Hence the student will, if an intelligent and rational individual, know that an inquiry into the principles of his art, although it may influence but little his practical pursuits, is a laudable and legitimate one for him, and cannot fail to give him higher and more enlarged views.

Supposing him then to persist in his inquiry, he would naturally examine more carefully some of the theoretical books on his art, in which he would find, scattered here and there, attempts to ascribe some of the elements of music, chiefly the rules of harmony, to natural laws. But he would soon infer, from the haze of uncertainty and controversy in which these attempts were enveloped, that they failed to show any firm scientific or logical basis, and that, in any case, their scope and aim were too vague and too meagre to offer any satisfactory solution of the problems before him.

The information he would seek must be sufficiently wide in its range to embrace the whole structure of the art, and it would, if reduced to a system, be a "Theory of Music" in the highest and truest sense. It is proposed in the present work to show what has been done towards the improvement of this branch of musical knowledge; but on account of the uncertain and indefinite meanings which have become attached to the word "Theory," it has been thought better, for an inquiry so essentially philosophical, to adopt the term which appears on the title-page.

The first serious attempt to establish a philosophical theory of music was by the late Moritz Hauptmann, one of the most eminent musicians of the present age, and for many years head of the celebrated Thomas School at

Leipsic. In 1853 he published a book entitled, "Die Natur der Harmonik und der Metrik, zur Theorie der Musik." It was a work involving great thought; but, unfortunately, the author, who had deeply studied German philosophy, built his theory on transcendental metaphysics, borrowed chiefly from the system of Hegel. We shall have occasion now and then to notice some of Hauptmann's ideas; but his theory generally is so difficult to follow, and, when made out, so unsatisfactory to minds of ordinary calibre, that the book, meritorious as it is, has for the most part fallen dead on the world.[1]

A few years later another eminent German philosopher attacked the problem in a way far more successful, namely, from the side of physical science. This philosopher was Hermann Helmholtz, then professor at the University of Heidelberg; and the result was the publication of his great work on musical acoustics, now so well known.

It was natural that the most satisfactory explanations of musical facts should be looked for in the laws and phenomena of sound; but before this time little had been done. The general and more simple data of acoustical science had been tolerably well understood, but it was reserved for Helmholtz to study more closely and satisfactorily such of them as had reference to musical tones, and to carry his investigations into the philosophical structure of music itself.

The work appeared in 1863, and was entitled, "Die Lehre von den Tonempfindungen, als physiologische Grundlage für die Theorie der Musik," which may be freely translated, *The Doctrine of the Perception of Musical Sounds, considered as a Physiological Basis for the Theory of Music.*

The author is not only a profound and practised physicist and physiologist, but he has the great advantage of a

[1] A far more interesting, though less pretentious, work by this eminent man is his "Briefe an Franz Hauser," in which a vast amount of valuable and thoughtful matter is to be found.

competent knowledge of music, both theoretically and practically; and it is to this happy and unusual combination of qualifications, added to a clearness of thinking and writing somewhat rare among his countrymen, that are due the great success of his labours and the great popularity they have attained.

The work on its first appearance met with high and universal appreciation among those who could understand it, and in Germany, where both scientific and musical criticism may be supposed to be particularly advanced, it has had the approving stamp of passing through three editions. It has also been published in French, which has given it a still wider European circulation, and a few years ago it was made accessible to our own countrymen by an excellent English translation.[1]

It was the aim of the author of this work to bridge over the great gulf that previously existed between the science of acoustics and the art of music. He says, in his introduction—

"In the present work an attempt will be made to form a connexion between the boundaries of two sciences, which, although drawn together by many natural relations, have hitherto remained distinct, the boundaries of *physical and physiological acoustics* on the one side, and of *musical science and æsthetics* on the other.

"The horizons of physics, philosophy, and art have of late been too widely separated; and as a consequence, the language, the methods, and the aims of any one of these studies, present a certain amount of difficulty for the student of any other of them.

"It is true that acoustics constantly employs conceptions and names borrowed from the theory of harmony, and similarly manuals of thorough bass generally begin with a physical chapter.

"But up to the present time this apparent connexion of acoustics and music has been wholly external, and may be regarded rather as

[1] On the Sensations of Tone, by Hermann L. F. Helmholtz. Trans- mans, 1875. All references are made to this edition.

an expression given to the feeling that such a connexion must exist, than its actual formulation.

"Physical knowledge may, indeed, have been useful for musical instrument makers, but for the development and foundation of the theory of harmony it has hitherto been totally barren."

The work consists of two parts, which, although they are of necessity a good deal mixed up in the author's treatment, are really very distinct. They may be called the physical and the musical parts respectively.

In the first place, the author treats of matters purely acoustical;—of the nature of musical sounds; of the mode of their perception by the ear; and of certain physical and physiological phenomena attending them, either singly or in combination. This portion of the work contains much matter of great importance, involving many facts and views either novel in themselves or treated and reasoned on in a novel manner; and the interest attaching to it has been promptly seen by scientific men, who have hastened to present to the public, in simplified forms, the essence of its contents. It is sufficient to refer to the admirable works of Dr. Tyndall and Mr. Sedley Taylor[1] for clear and compendious accounts of Helmholtz's researches in the physical branch of his subject.

But Helmholtz's work has a much wider scope than the merely physical one. His title implies not only the investigation of the nature and perception of musical sounds, but also the application of this to form a basis for the theory of music. Accordingly, he has devoted a large portion of his book to this object. He first solves a great problem, long considered obscure, as to the nature of consonance and dissonance, and he then goes into an elaborate philosophical analysis of the whole structure of music, with the view of investigating how far its elements may be referred to the physical principles of sound, which he has previously established, or how far their existence

[1] Sound. By John Tyndall, D.C.L., LL.D., F.R.S. Third Edition. London, 1875. Sound and Music. By Sedley Taylor, M.A. London, 1873.

and nature must be explained and accounted for on other grounds.

This latter part of Helmholtz's work has yet received ittle attention, although really it is the part which has ost interest to the musician.[1] From the prominence ven to the physical portion, an idea has sprung up, and pretty generally entertained, that it is in the doctrines physical acoustics that the "theory of music" is to be nd and studied. Such an idea can only have arisen m a misunderstanding of Helmholtz's labours, and a nt of appreciation of the great pains he has taken in gard to matters purely musical. It is impossible to tudy his book carefully without perceiving that, notwithtanding the importance of his acoustical discoveries, and eir admirable and ingenious application, a very large roportion of the philosophy of music lies altogether outside the physical boundary.

It cannot be concealed, however, that the musical part of Helmholtz's work is very difficult. His researches embrace topics which are, generally speaking, abstruse and unfamiliar; and to appreciate fully the bearing of his investigations on the ordinary aspects of music, requires not only much industry and perseverance, but a somewhat rare combination of high scientific and technical knowledge.

It is no doubt for this reason that, while the physical part of Helmholtz's book has been so well popularised, his musical researches are comparatively little known.

It will now be understood that the "Philosophy of Music," as established by the investigations of Helmholtz, implies not the bare enunciation and explanation of acoustical phenomena, but the general philosophical ana-

[1] Dr. Tyndall says in the work referred to (p. 376)—"You have thus accompanied me to the verge of the physical portion of the science of acoustics, and through the æsthetic portion I have not the knowledge of music necessary to lead you."

lysis of musical structure, to which the acoustical element is only introductory, and which really extends into a much wider domain.

It is the object of the present work to give some account of this philosophy, with the view of simplifying its appr hension, especially by musicians, to whom the labo required by the study of the work itself must render almost a dead letter.

It must, however, be understood that the present li book is in no wise to be regarded as a substitute for He holtz's Treatise, which can be referred to by those v would study, in more complete detail, the large range topics comprised in his investigations. For this reason th author has ventured, while strictly following out Helm holtz's principles, to give to his own explanations an ind pendent form, which his practical experience in musi leads him to think will be most easily intelligible to the readers he is addressing.

Before entering on the inquiry, it will be well to define with some precision what its nature and scope should be; and for this purpose we must begin by the question, What is music?

Music is formed from sounds of peculiar kinds, which, after being selected from certain elementary series called scales, are combined and arranged into a complicated structure at the will of the composer. This definition points to three heads of inquiry, namely, the material, the primary or elementary arrangements, and the final or complex structure.

In the first place, we must inquire into the nature of the material with which we have to deal in music, this material being musical sounds. It is consistent with analogy that when we have to investigate the principles that guide the formation of a structure, we should see how far these will be dependent on the character of the material to be used. For example, if we have to build a

tower, it will be constructed very differently, according as it is to be of stone, of iron, or of wood; the special properties of each clearly influencing the mode of its application. Similarly we must inquire into the peculiar properties of musical sounds, in order to see how these properties may influence the structure to be formed. In this part of the inquiry, which is strictly physical, we shall find the acoustical discoveries and demonstrations of Helmholtz of the highest value.

Secondly, we must inquire into the nature of the simplest elementary modes in which this material is arranged or prepared for use. We find the sounds disposed in series of peculiar construction, known by the name of "musical scales;" and these present many peculiarities that must be inquired into and explained.

Thirdly, having studied the elementary or preparatory arrangements, we are in a position to pass on to the more complex structure of music itself. And in doing this we must distinguish between two varieties of music, which have very different characters, namely, Melody and Harmony.

The simplest kind of music is when one voice or one instrument executes a succession of different sounds, one at a time; as when a tune or air is sung by a voice or played on a flute or violin. This is called *Melody.*

A more complex kind is when several different musical notes are combined or sounded simultaneously. This is termed *Harmony.*

And there is another variety more complicated still, in which several melodies may be performed together, producing harmony by their combination. This is called *Counterpoint,* and is the highest and most refined all.

Modern music consists more or less of all these contains, moreover, an element founded on the dura of the various sounds, introducing what are called *ti*

measure, and *rhythm*; and there is yet another feature of interest, affecting the general design of any piece as a whole, called *form*.

In a Philosophy of Music all these things must be inquired into; and when we come to matters of arrangement and structure, whether elementary or complex, we cannot fail to notice the fact that music is constructed according to certain *forms* which are tolerably well defined, and which either are laid down as *rules of composition*, or may be clearly inferred by examination of the works of the best masters. Some of these forms are of ancient origin, and appear to be little susceptible of variation; while others are of more recent introduction, and are more subject to change.

Hence the problem before us will chiefly resolve itself into a philosophical inquiry as to the nature, the origin, and the foundation of these forms.

And, broadly speaking, we may fairly assume that the principles which have determined or influenced them, may be classed under two distinct heads, namely, *physica* principles and *æsthetical* principles.

By physical principles are meant such principles as can be deduced, according to the laws of natural science, from the physical nature of musical sounds, and from their known physiological effects on the human ear.

By æsthetical principles are meant such principles as have resulted from the free action of the human mind, independently of any physical considerations.

In further explanation of the distinction between these two sets of principles, a few passages may be quoted from Helmholtz, who was the first to give this distinction its ...e weight. He says (p. 357)—

have analysed the sensations of hearing, and investigated ...hysical and physiological causes for the phenomena discovered, ...ing solely with natural phenomena, which present themselves ...echanically, without any choice, to the ears of all living beings.

"But in our inquiry into the elementary rules of musical composition, we tread on new ground, which is no longer subject to physical laws alone; we pass on to a problem which by its very nature belongs to the domain of æsthetics.

"The altered nature of the matters now to be treated betrays itself by a purely external characteristic. At every step we encounter differences of taste, historical and national. The boundary between consonances and dissonances has been frequently changed. Similarly scales, modes, and their modulations have undergone multifarious alterations, not merely among uncultivated or savage people, but even in those periods of the world's history and among those nations where the noblest flowers of human culture have expanded.

"Hence it follows (and the proposition cannot be too vividly t to the minds of our musical theoreticians and historians) *system of scales, modes, and harmonic tissues does not rest solely nalterable natural laws, but is at least partly also the result of ical principles, which have already changed, and will still further e with the progressive development of humanity.*"

he investigation of these æsthetical principles is as portant a part of the philosophy of music as that of e physical ones; but unfortunately the ground here is nuch less stable, as the nature of the influences that have een at work is much more obscure.

Helmholtz holds the view that in many cases the æsthetic nciples which have ruled the forms of music have not n arbitrary, but have been derived from some more eral laws that admit of being studied and determined. conceives that the artists who have originated these ns have done so unconsciously, according to some ural promptings which have forced upon them the imate attainment of the best forms of combination. Hence he believes that in these cases science ought to be capable of discovering the motive forces, whether psychological or technical, which have been at work in this artistic process, although the task is not always an easy one.

The object here in view, therefore, is to examine, in

detail, the various forms and rules of musical structure, and to inquire how far they are derived from physical principles, or how far they have been the result of æsthetic or artistic considerations.

The notion most generally prevalent among musicians, and embodied most frequently in works which pretend to treat of such matters, is, that the modern forms of musical structure, from the simple diatonic scale up to the more detailed rules of harmony and counterpoint, rest on some imperative natural laws, which will not admit of violation, or scarcely of alteration. The cause of this consists chiefly in a loose and indistinct idea of what nat- laws mean, and in a fallacious appeal to the judgm the ear, mistaking the force of education and habit promptings of nature. We shall have many exampl this to point out in the details of our inquiry.

The investigations of Helmholtz, however, by exp ing now for the first time the true nature of our mus sensations and perceptions, have exposed these fallac and have rendered possible a more correct and exa analysis of musical structure. We shall find that while it is possible to trace the simpler elements of music clearly back to acoustical principles, this connection does not g very far; for when the inquiry reaches the more comp stages, the acoustical explanations will fail, and recou must be had to more artificial sources of action. fact is, that the more elaborate forms and rules of mus structure have gradually grown up by a long process evolution under the hands of the masters of the art composition, guided either by feelings of the æsthe effect on the mind of the hearer, or by considerations artistic expediency—causes altogether different from those ordinarily assigned.

The inquiry, though strictly theoretical, is not without a practical bearing, as it directly influences the weight and authority of the rules and forms. So far as these can be traced to acoustical principles, they take a more fixed and

authoritative character; but when they result from ch…
and judgment, though they may be worthy of all respe…
they are of less stability. For as they have been prompte…
under certain circumstances by certain influences, an alteration of the conditions may lead to their being abandoned, or superseded by other forms. Such changes are precisely analogous to those produced by the influence of environment, in ordinary biological evolution.

It must be understood that this work only professes to discuss the nature and origin of musical forms. It is no part of its object to enter upon a very wide and difficult subject which lies beyond, namely, the general effect produced by music on the mind, as depending on its composition and style. This is rather the *Psychology* than the Philosophy of music, and it constitutes a most obscure and intricate problem of musical æsthetics, which it would be vain to attempt to treat, in combination with the strictly technical scope of this treatise.

It is only very lately that serious attention has been given to this subject by competent writers. It is true that the enormous power of music over the feelings and the emotions of mankind has been long known, and has frequently formed the subject of poetical allusions; but the more prosaic attempts to describe or explain it, often by persons ignorant either of music, or of psychology, or both, have usually amounted to little more than highflown sentiment or unmeaning twaddle.

The true nature of this power, and the mode of its action, have been generally regarded by more enlightened and more accurate thinkers as an almost inscrutable mystery. Even Helmholtz, who has said so much of the æsthetics of music, has only allowed himself to touch lightly here and there on the fringes of the question. Indeed, he says, with great force and truth (page 568):—
"The æsthetic analysis of complete musical works of art, and the comprehension of the reasons of their beauty,

'unter apparently invincible obstacles at almost every p."

It must, however, be admitted that he himself has for the first time made the psychology of music a possible science, by clearing the ground of the obstructions caused by former fallacies, and by placing the perceptions of music on the firm basis of philosophical truth. No doubt the qualifications for the study are rare, and consequently the labourers in the field are few; but considering the short time that has elapsed since the scientific data of the problem have become known, something has been done towards its discussion, and there is every prospect that it will receive the attention of competent investigators.[1]

It will be assumed that the readers of this work are acquainted with written music, so far as it is ordinarily taught for practical purposes. Anything beyond this wil' be explained as required.

[1] Among the writers on this subject may be mentioned the following:—

Herbert Spencer, "The Origin and Function of Music," published in *Fraser's Magazine*, 1857, and reprinted in "Essays Scientific, Political, and Speculative."

Charles Darwin, Remarks on the same subject in "The Descent of Man" and "The Emotions."

James Sully, three most thoughtful and original essays, published in 1874 in a series called "Sensation and Intuition," now, unfortunately, rare.

Edmund Gurney, "The Power of Sound," 1880, a voluminous work, containing much admirable matter, and many novel views.

The Germans have, as might be expected, earnestly interested themselves in this subject. Among early writers on the æsthetics of music, the best known are Hanslick, Schopenhauer, and Hand; but as these came before the development of the acoustical knowledge, they are hardly to be included in the present category.

In later years, the writer who appears to have made the subject specially his own, is Dr. Carl Stumpf, Professor of Philosophy in the German University of Prague. He published in 1883 the first volume of a large work called "Tonpsychologie," which promised to be an exhaustive treatise, but no further part of it has yet appeared. In 1885 he wrote a long article in the Leipsic "Vierteljahrschrift für Musikwissenschaft," entitled "Musikpsychologie in England," in which he has reviewed and commented at much length on the English works and papers above-named.

PART FIRST.

THE MATERIAL OF MUSIC.

CHAPTER II.

THE PHENOMENA OF SOUND IN GENERAL.

In considering the nature of the materials used for forming the structure of music, namely, musical sounds, it would be proper to begin with an elementary explanation of the phenomena of sound in general. This lies, however, strictly within the domain of the science of acoustics, and it is no part of the design of the present work to supersede the excellent treatises and handbooks already existing on this subject.

The first complete work on the science was that of Dr. E. F. F. Chladni, of Wittenberg, in Saxony, "Die Akustik," published in 1802. It was translated into French, it acquired a high and wide reputation, and has always been considered a standard authority, so far as the knowledge of the subject extended at that time.

This was followed in 1845 by a treatise in the "Encyclopædia Metropolitana," by Sir John Herschel, in a more advanced form, and in the admirably clear style for which that great man was so deservedly famed.

The modern work of Helmholtz comes next in order, with its later popular expositions by Dr. Tyndall and Mr. Sedley Taylor, which, so far as the acoustical element in the philosophy of music is concerned, leave nothing to be desired.

The more abstruse mathematical theories of the science have been well presented by the Astronomer Royal, Sir George Airy, in "Sound and Atmospheric Vibrations,"

1868; by the late Professor Donkin of Oxford, in "Acoustics," 1870; and by Lord Rayleigh, in "The Theory of Sound," 1878.

These works must be referred to by those who would master this branch of the subject. It will be sufficient here to describe very briefly, and in the most elementary way, a few of the more important general phenomena.

Sound is a sensation caused, in the first instance, by certain oscillatory motions of the particles of a body; the effect of these motions being transmitted through some medium, generally atmospheric air, to the ear, where they produce impressions on the nerves, corresponding to the nature of the original motions causing the sound. Hence the subject naturally divides itself into three branches—first, the *production*; secondly, the *transmission*; and thirdly, the *perception* of sound.

Production of Sound.

Sound may be produced by any kind of motion that has a certain suddenness and energy. If such motions are irregular, they produce *noises*, which may have great variety, according to the nature of the exciting cause, and are scarcely capable of analysis. But when the motions of the sounding body are repeated regularly and similarly at exactly equal and very small intervals of time, the effect loses the indefinite noisy character, and becomes more uniform and agreeable, forming what is known as a musical sound.

To produce this kind of effect the most favourable condition is that the body should be elastic, and that its action should consist of the vibratory motion or oscillation of its particles, and this is the usual mode of production of musical sounds. Thus if an elastic string is tightly stretched over two bridges, and is struck by a hammer, pulled by the finger, or scraped with a rosined bow, it is set into vibratory or oscillatory motions that give rise to

sounds. Many other elastic bodies, such as metal bars or tongues, stretched membranes, &c., may be made to give out sounds in like manner. And even the air itself may serve as the origin of sounds, for there are many ways in which vibratory motions may be set up in it without its being excited by any antecedent oscillatory action.

In all these cases, it is the elasticity of the bodies which is chiefly effective in giving to the particles their *regularity* of motion, and so in producing the musical quality of the sound. This effect is the result of well-known mechanical laws, and the character, extent, and velocity of elastic oscillations may be, and have been, calculated and determined by mathematical means with great accuracy.

The vibrations of an elastic sounding body may vary in three respects—namely, in *rapidity*, in *extent* or *amplitude*, and in *form*.

Thus, for example, taking a stretched string as the simplest illustration, it is easy to trace the existence of all three variations. In the first place, it may be seen that a long, or heavy, or slack string will vibrate slower than a short, or light, or tight one, exemplifying the variation in rapidity. Secondly, if this string is pulled or struck violently, its oscillations will be wider, it will depart farther from its normal straightness, than when it is pulled or struck gently; so exemplifying the variation in extent. Thirdly, it is easy to imagine, or even in certain cases to observe, that different modes of excitation of the string may cause it to take different shapes in its oscillations; this illustrates the variation of form. The same variations exist in all elastic sounding bodies, though they are often much less obvious, and more difficult to trace.

Each of these three variations in the character of the sound-producing vibrations, has a peculiar and very important significance in a musical point of view; as will be explained more definitely in the next chapter.

Transmission of Sound.

The bodies that produce the sound being generally at some distance from our ears, the effects of the vibrations have to be transmitted thereto through the intervening medium, which is usually atmospheric air.

This mode of transmission is one of the most complicated points of acoustical science; difficult to understand, and still more difficult to describe. It would be out of the question here to give any complete account of it; all that can be done is to give some brief descriptions which may, perhaps, make intelligible the general nature of the phenomena it involves.

The transmission of sound through the air takes place by the formation of aerial elastic *waves*, which are propagated through the fluid medium with great velocity and ultimately enter the ear. These are in some respects analogous to waves formed on water, but with the difference that, whereas the latter are at the surface, aerial waves exist in the mass of the air itself. This is rendered possible by the elasticity of the air, which allows of its being either compressed, or expanded, under slight forces applied. The effect of the slight blows given to the air by the vibrations of the sounding body, is to produce slight compressions and expansions of the circumambient air, and these, being propagated to a distance through the fluid, form the waves. Each wave is of a compound nature, consisting partly of compressed, and partly of expanded air, and one complete wave is produced by each complete vibration of the sounding body.

These air-waves have the property of moving forward, in a manner analogous to the motion of waves on the surface of water. The sudden impulse of a vibrating body on the adjoining particles of air, forming, say, a momentary compression therein, is transmitted forward to the next adjoining particles, from these to the next, and so on, so as to produce a propagation or travel of the compressive action, without any necessary motion of the general body of air.

Now, we happen to know by observation the rate at which such compressive action will be propagated, this being another name for the *velocity of sound.* It varies with the state of the atmosphere as regards temperature and density; but it is, under ordinary circumstances, about 1100 feet per second, *i.e.*, the impulse given by the motion of any vibrating body, will propagate itself through the air at this velocity.

Knowing this, we can determine, with some precision, the magnitude of the air-waves corresponding to certain sounds. An example will best show this. Suppose the sounding body to be one which makes 256 complete vibrations in a second, corresponding, as will be explained in the next chapter, to about the note called "middle C," the result will be that the sounding body will give a series of regular impulses to the air, occurring at intervals of $\frac{1}{256}$ of a second. Supposing, then, one of these blows to be given, causing a compression in the air adjoining, this compression will be propagated through the air at the rate of 1100 feet in a second, and consequently, when a repetition of the blow comes, in $\frac{1}{256}$ of a second, it will have advanced $\frac{1100}{256}$, *i.e.*, 4.28 feet. By the repetition of the blow a new wave will be originated, precisely similar to the former one, and thus the sounding body will go on generating a series of waves, each 4.28 feet long, and all flying off into space, with the velocity known as the velocity of sound. This length of 4.28 feet is therefore the *length of air-wave* corresponding to the note "middle C."

The constitution of an air-wave, taken between its extreme boundaries, is, as has been said, of a compound nature. In a part of it the air is compressed, in another part of it the air is expanded; and a fair idea may be formed of this constitution by returning to our simile of waves upon water. A complete water-wave consists partly of an elevation above, and partly of a depression below, the normal water level; and if we imagine the former to

be analogous to the compression of the air, and the latter to its expansion, we may understand how the different components may be arranged.

It may also be easily imagined that in different waves the disposition of the compressed and expanded parts may be different, giving rise to different *forms* of wave. It is also clear that, though the form may be the same, the disturbance of the particles, *i.e.,* the degree of compression or expansion, may vary, giving rise to different *intensities* of waves, just as on the water some waves may be high and violent, others low and gentle.

It will now be intelligible how the aerial waves will correspond with, and will therefore transmit, the several different properties of the original vibrations of the particles of the sounding body.

In the first place, it has been already explained how every new vibration will originate a new air-wave, each flying off into space at a certain velocity; so that the *rapidity* of the original vibrations will be represented, inversely, by the length of the wave; double the rapidity of vibration giving half the length of wave, and so on.

Secondly, as the vibrations are more powerful, they will naturally produce greater disturbance of the particles of the air, so that the *amplitude* of the original vibrations will correspond with the intensity of the disturbance in the air-waves.

Thirdly, the variations in the *form* of the vibrations will produce corresponding variations of form in the air-waves.

And in regard to this point there is a principle which, as applied to music, is of much importance. It is, that a simple musical sound (*i.e.,* a sound not compounded of several, as most musical sounds are) always gives rise to a certain form of air-wave, only varying in its length and its intensity. The more complex forms

of waves are produced by the combination of several simple sounds together. It is true that each sound will tend to produce (just as if it were sounding alone) its own particular form of wave; but since these cannot exist separately in the same mass of air, they will combine, and their combination will constitute a complex form of wave. And conversely, according to a certain mathematical law called *Fourier's theorem,* it is demonstrable that any regular periodic form of compound air-wave may be resolved into a number of simple ones, which may be discovered, and their properties identified.

The obscure and difficult subject of air-waves has occupied the attention of the most eminent philosophers, who have brought to bear on it all the array of the highest mathematical science. The problem was first undertaken by Newton, and its fullest modern development will be found in the works already mentioned.

Perception of Sound.

The final step in the acoustic process, namely, the reception of the aërial undulations in the human ear, and the transmission of the sensations to the brain, has not been less studied than the former ones; and anatomists and physiologists have succeeded in explaining so much of the process as can be traced by physical inquiry. But to go into the minutiæ of these investigations would be out of the question here. We must content ourselves with a few statements of the simplest kind.

At the end of the winding orifice of the ear is a membrane covering a hollow space, like a drum, and beyond this lie a succession of organs of very complicated character, the object of which is to transmit to the auditory nerves, and so to the brain, the sensations received upon the external drum membrane. When an air-wave arrives at the ear it is propagated along the passage, and the vibrations or oscillations which form it cause corresponding tremors in the drum membrane; these are communicated

to the auditory nerves, and thence to the brain, and so we get the sensation of sound.

And since all the peculiarities of the construction of the wave—its length, and the degree and form of the disturbance of its particles—make themselves individually distinct upon the membrane, the sensorium thereby is enabled to appreciate the varieties in the sounds to which these peculiarities correspond.

Under the last head it was remarked that when several musical notes sound simultaneously, their combined effect is transmitted through the air in one single wave of a compound form. It might be supposed that the only effect of this on the ear would be a confused noise, something analogous to the impression which the mixture of a number of different-coloured pigments would produce on the eye.

The reason why this is not so is on account of a wonderful faculty which the human ear has of *analysing* any compound wave submitted to it; of resolving it into its component elements, and of presenting those elements separately and independently to the mind. This is expressed by what is called the *law of Ohm*, which is, that the ear refuses to recognise any sound-wave unless of the simplest form; and that, consequently, the only means it has of treating a compound wave is to find out of what simple elements it consists, and to make these separately audible.

In order to form an idea of the extent of this power, imagine the case of an auditor in a large music room, say a promenade concert, where a full band and chorus are performing. Here, speaking first of the music, there are sounds mingled together of all varieties of pitch, loudness, and quality; stringed instruments, wood instruments, brass instruments, instruments of percussion, and voices of many different kinds. And in addition to these there may be all sorts of accidental and irregular sounds and noises,

such as the trampling and shuffling of feet, the hum of voices talking, the rustle of dresses, the creaking of doors, and perhaps the gurgling of fountains, and many others.

Now, be it remembered, the only means the ear has of becoming aware of all these simultaneous sounds is by the peculiar mode of condensation and rarefaction of some particles of air at the end of a tube about the size of a knitting needle, forming a single air-wave, which, though so small, is of such complex structure as to contain in itself some element representing every sound going on in the room. And yet when this wave meets the nerves, they, ignoring the complexity, single out each individual component element by itself, and convey to the mind of the auditor, without any effort on his part, not only the notes and tones of every instrument and class of voice in the orchestra, but the character of every accidental noise in the room, almost as distinctly as if each single sound or noise were heard alone! Truly in the science of acoustics, when we treat of those parts where the human powers come into play, there are depths which are unfathomable!

CHAPTER III.

SPECIAL CHARACTERISTICS OF MUSICAL SOUNDS.

It is now necessary to treat, in more detail, of certain properties which characterise musical sounds. This also is a part of acoustics proper, and may be studied in the books already cited. But, inasmuch as we come here much closer to the musical application of the science, it is desirable, even at the risk of repeating what may be found elsewhere, to give a general explanation of these properties. There will, after all, be much left for further study on the part of those inquirers who desire to go to the root of the matter.

It has been pointed out in the last chapter that there are three varieties in the character of the original vibrations of an elastic sounding body, and that these correspond to three analogous variations in the constitution of the air-waves which transmit the sound to the ear. These are—

I. The vibrations may vary in *rapidity*;—corresponding to variations in *length* of the transmitting air-wave.

II. The vibrations may vary in *amplitude* or extent;—corresponding to variations in *intensity* of the transmitting air-wave.

III. The vibrations may vary in *form*;—corresponding to variations in form of the transmitting air-wave.

Now these three variations have a direct practical significance, inasmuch as they correspond, respectively, to three practical properties of musical sounds, which are

familiar enough to every one accustomed to music. These are—

I. The *pitch* of the sound.
II. The *strength* of the sound.
III. The *character* of the sound.

Each of them is subject to a wide variability, and each is directly related to the corresponding variable property of the vibrations of the sounding body, and of the transmitting air-wave.

It will be our business, in this chapter, to investigate these relations in regard to each property.

The pitch of musical sounds.

The word *pitch*, in its general sense, refers to the position of any sound in the musical scale of acuteness and gravity.[1] The distinction between what are called "high" and "low" notes is sensible to everybody: each note of a pianoforte is "higher" in pitch than its left-hand neighbour, and "lower" than its right-hand one. And the

[1] The application of these terms is not easy to account for, for there is nothing in their natural meaning to warrant literally their application, nor are they consistent, as one is not the opposite of the other. They are, however, as old as the Greeks, for Aristides Quintilianus used ὀξὺς to denote the quick vibrating sound, and βαρὺς to denote the slow vibrating one, and these terms have been transmitted through the Latin *acer* and *gravis* down to our day. It would be idle to speculate how they originated; probably the peculiar piercing effect of quick vibrating notes on the ear may have suggested the former, while on the other hand slow vibration sounds, being produced from the longest strings, the largest pipes, and the heaviest instruments generally, may have suggested the latter.

In regard to the terms "sharp" and "flat," the former is a synonym for acute, and the latter is a better opposite to it than grave; but still the idea of a note of slower vibration being "flatter," *i.e.*, of a more even and level surface than a quick vibrating one, is incomprehensible.

But the two other words, "high" and "low," most used of all, are at the same time the least intelligible, for there is no imaginable connection between any number of vibrations per second, and any degree of elevation above the earth's surface. They were, however, also used in very early times; and when musical notation first arose by the use of the relative *position* of marks or points, the idea was seized on to guide such positions (the paper being supposed to be placed vertically), and thus the connection between "high" notes and quick vibrations has become firmly implanted in our minds.

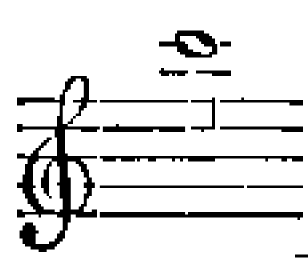
difference in pitch may be much less in degree than this interval, and still be very evident; as, for example, when we speak of an instrument being a little "too sharp," or of a vocalist singing a little "too flat," which are only common expressions to signify small variations of pitch above or below some imaginary standard.

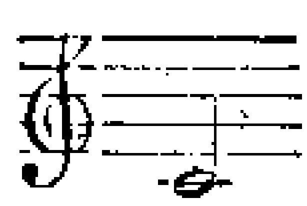
Now the pitch of a musical sound is determined by the *rapidity* with which the vibrations of the sounding body succeed each other. The quicker the succession of the vibrations, the *higher* is the pitch of the note; the slower the succession of the vibrations, the *lower* is the pitch.

It follows from this, that every musical note that we can form any conception of has a certain rapidity of vibration peculiar to itself; and hence the *number of vibrations* per second, or, as it may be called for brevity, the *Vibration Number*,[1] becomes an accurate definition of the *pitch* of any sound.

Thus, for example, 512 vibrations per second will produce a note that may be represented by the musical sign

 while 1024 vibrations per second will produce

the note  and 256 vibrations per second will

produce the note 

The vibrations here mentioned are what are called "double" ones; each consisting of a complete double oscillation, forward and backward, corresponding to a complete air-wave. Chladni measured by single vibrations, which are analogous to the estimation of the

[1] Lord Rayleigh uses the word *frequency* for the number of vibrations in a given time, but the one adopted in the text (which I believe is due to Mr. Sedley Taylor) appears the best for practical purposes.

beats of a pendulum; but the double vibration was originally used by Newton, and is now most generally adopted. All vibrations spoken of in this work will be understood to be double ones.

There are certain limits of rapidity of vibration beyond which the sounds produced cease to be audible to the human ear. These limits are not perfectly defined, as some ears are more sensitive than others in this respect; but it is generally considered that the lowest audible sound corresponds to about 16 vibrations per second, and the highest to about 38,000, giving a range of about eleven octaves.

It may naturally be asked, How is it possible to count vibrations succeeding each other with such rapidity, and to ascertain what number of vibrations per second correspond with any given musical note? There are several modes by which this may be done.

One of the earliest and simplest devices is what is called *Savart's ratchet wheel.* A wheel having teeth on its circumference is made to revolve, and a tongue of card is held against it. The passage of the teeth gives a vibratory motion to the tongue, which, if quick enough, will give a musical sound. Hence, as the number of revolutions of the wheel in a given time can be noted, the number of vibrations corresponding to the note can be found.

Another mode, more accurate, is by an instrument called the *Siren.* By means of a revolving disk which alternately opens and closes holes in a box filled with compressed air, puffs of wind are allowed to escape at regular intervals; these set the air in vibration, and produce a musical note, and by counting the revolutions of the disk, the number of vibrations in a second can be accurately ascertained.

Again, the number of vibrations made by a string sounding any note can be deduced, by mathematical rules, when the length, weight, and tension are accurately known, as will be explained in the next chapter.

There are also ingenious devices by M. Lissajous, and by Messrs. M'Leod & Clark, by which the vibrations of a tuning-fork can be made observable, and counted, by optical means; and there are also contrivances, particularly those by Professor Mayer and Lord Rayleigh, by which the same vibrations can be made to record themselves upon paper.

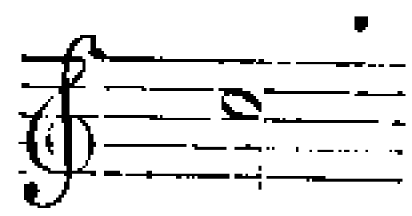
Then, finally, vibrations can be counted by means of the phenomena called "beats" (see Appendix, Note D), a method which has been carried to great perfection in the tonometers of Scheibler and Appun.

These various contrivances will be found more fully described in works on Acoustics. The several methods of determination, based on different principles, serve to check each other, and the results they have given correspond so well as to give great confidence in our power of scientifically defining the pitch of a musical note by its number of vibrations in a second of time.

It follows from what has been said that the number of possible notes all differing from each other in pitch, is theoretically unlimited, inasmuch as any difference in the vibration-number will certainly give rise to a different sound. Practically, also, the number is very large, depending only on the sensitiveness of the ear for minute differences of pitch; a skilful pianoforte tuner, for example, is obliged, in the exercise of his art, to distinguish between a true and an equally tempered fifth, the difference being only about *one-fiftieth of a semitone*, which would give 600 distinguishable sounds in the octave! The pianoforte has only 12 sounds in the octave, but the intervals between them may be easily divided into several parts, and it is usual to estimate that from 50 to 100 sounds in the octave may be distinguished by ordinary ears.

Since every possible musical sound corresponds to a definite and known velocity of vibration, it may be thought

that any note used in music ought to be at once positively and unmistakably connected with its proper vibration-number. This, however, is not so, the reason being that at present there is no definite standard, no general agreement among musicians, as to the exact place in the infinite scale of possible tones where any nominal musical note should stand.

An example will render this clear. Let us take the note treble C, indicated in music by the sign  and let us suppose that some competent inquirer wished to ascertain for himself what was the vibration-number corresponding to this note. If it were sounded to him by an old organ or an old pitch-pipe, he would probably find it something near 500: Westminster Abbey organ would give him 518; a new piano of Broadwood's would give him 526; and a modern opera band, on a hot summer evening, would give about 545. The highest of these examples would be about a semitone and a half different from the lowest, and he would find, in different cases, all sorts of intermediate values for this note called treble C.

This opens the question of the *Standard of Pitch*, one which has been much debated.

It stands to reason and common sense that there ought to be some common agreement among the musicians of the world as to what musical note should be denoted by a certain musical sign; but unfortunately there is no such agreement, and the question is therefore still undetermined.[1]

There is reasonable evidence that from the time of Handel down to the death of Beethoven, during which period the greatest musical works extant were written, the pitch ordinarily used was (always referring to the treble

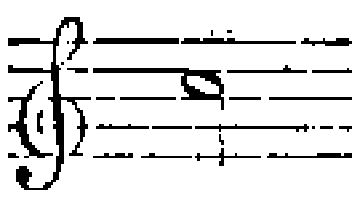
[1] An elaborate discussion of the question of pitch will be found in a paper read before the Society of Arts, by Mr. A. T. Ellis, on 25th May 1877.

C) somewhere between 500 and 520. Since that time it has risen considerably, and the modern English orchestras are tuned to about 540.

This rise, however, has been objected to, and the French have established by law a standard of  = 435, which gives treble C (by equal temperament) = 517. This pitch is now also generally adopted in this country for church and cathedral organs, and for all vocal music when unaccompanied by an orchestra.

Although, however, practice differs so much in regard to the pitch, it is desirable, on philosophical grounds, to determine on some standard by which the position of musical notes can be theoretically defined; and fortunately there is a very easy and very satisfactory means by which this can be done.

Let us inquire what note would be given by the simplest rate of vibration, *i.e.*, one double vibration per second. We cannot tell this by actual experiment, for the reason that the sound would be inaudible. But since there is a well-known harmonic law (to be hereafter explained), that by doubling the vibration-number we raise any sound exactly an octave, we have only to go on doubling several times, and we get sounds that can be perfectly identified. For example, at the ninth doubling we get 512 vibrations per second, and we know that the note given by this will be exactly the same note as by one vibration, only nine octaves higher.

Now this note almost exactly corresponds with the  used in the time of Handel, Mozart, and Beethoven; and is very nearly the same as the French legalised pitch and the vocal pitch in England. And as the note C is the simplest note in our modern musical system, and the one generally used for a standard, we find that on this

pitch *the simplest rate of vibration produces the simplest musical note.*

We thus obtain a reasonably good standard of pitch, *i.e.*,  = 512. This has acquired the name of the *philosophical pitch*, and, as already stated, it corresponds fairly well with the actual pitch in the best musical times. It will be adopted throughout this work whenever the absolute pitch of notes has to be referred to.[1]

On the strength of musical sounds.

The second property attributed to musical sounds is their strength, or their degree of loudness or softness. The variations between sounds in this respect are familiar to every one; and as the cause of these variations is very simple, we may dismiss this head very briefly.

The degree of loudness of sound depends simply on the *amplitude* or extent of the vibrations, and the corresponding *intensity* of the disturbance of the air in the transmitting wave. If a pianoforte string, for example, is struck forcibly, it will be more deflected from a straight line, or will make larger vibrations, than when it is touched gently. These larger vibrations will communicate greater intensity of motion, in compression and extension, to the particles of the air, and will thus cause an impression of greater force to be made on the nerves of the ear, which is what is meant by a louder sound.

No philosophical scale of loudness and softness has yet been devised. Such a scale would be of use, not only on scientific grounds, but for purposes of practical utility, as

[1] By this standard the vibration number for C will always be some power of 2; so that 2^n *vibrations per second will always give the note C.*

Helmholtz uses a higher standard pitch, namely, C = 528, but nothing of importance turns on this, and therefore I have adhered to the standard I have always advocated.

It is worthy of remark that the philosophical pitch is given almost exactly by the Westminster bells, the key-note of which, "Big Ben," sounds an F of about 170 vibrations per

in "voicing" organ pipes, and regulating the tones of musical instruments generally; but there would be difficulty in making the determinations, owing to the deceptive effects of variations in *quality.* It would be found that some sounds have a more telling effect on the ear than others, owing, not so much to their real amplitude of vibration, as to certain peculiarities in their nature, and this disturbing cause must be eliminated before the true measure could be obtained.

The perception of loudness is diminished by distance from the source of the sound, as the amplitude of the oscillation of the aerial waves becomes weakened by wider propagation. Some late valuable researches by Professor Tyndall on Fog Signals[1] have also shown that the loudness of sounds transmitted through the air is subject to singular variations by changing conditions of the atmosphere; but it would be out of place here to go further into such a wide field of inquiry.

On the character of musical sounds.

The third property of musical sounds requires more lengthy notice, as its explanation introduces us to some physical elements which we shall find very important in the philosophical theory of music. It is the *quality* or *character* of the tone produced. A violin, for example, gives a tone of a different quality from that of a clarionet, an oboe, a flute, or a trumpet. We have no good English term to express this property; the French use the word *timbre;* but this is not so expressive as the German *Klangfarbe,* a word compounded of *Klang,* a musical sound or tone, and *Farbe,* colour. We must, however, be content with the homely expressions: quality, or *character* of tone.[2]

The varieties of character of tone that may be obtained

[1] Phil. Trans., 1874.

[2] Lord Rayleigh has adopted this word "character," and it seems to me on the whole the best for the purpose.

are almost infinite. We not only possess an immense number of musical instruments and means of producing musical sounds, all which have their individual qualities of tone, but even on the same instrument the same note may often be given distinct varieties of character, independent of the mere loudness or softness. And that these varieties are real objective physical differences, and not merely ideal, is proved by the facility with which an educated ear can identify and distinguish them, even sometimes to the minutest shades of difference. The stringed tribe of instruments, and still more the human voice, furnish ample examples of this. The tone of a particular violin, or of a particular violin player, can be identified by a connoisseur among a hundred, and we all know that the varieties of character of the human voice, even in the same register, are almost as diversified and as easily recognised by the ear as the varieties of physiognomy are by the eye. And even in the same voice, the numerous varieties of vowel sounds producible, are, when examined carefully, chiefly varieties in character of tone.

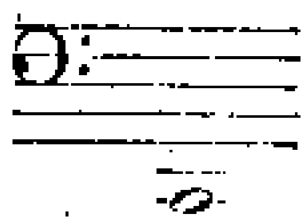
The nature and explanation of this property of musical sounds has been, down to a late period, very obscure. Chladni, the great expounder of acoustical science in the early part of this century, says, "Every real musical sound is capable of different modifications, whose nature is as yet entirely unknown, but which probably consist of some mixture of what is simply noise." He then explains at some length that this may arise either from peculiarities in the structure of the sounding body, as regards material, &c., or from the nature of the substance with which it is struck or rubbed to produce the sound. He further adds that differences of character may be due to irregular tremblings of the smaller parts of elastic bodies.

Sir John Herschel (*Encycl. Metrop.*), speaking of mu-

cular agitations on which they depend, we know too little to subject them to any distinct theoretical discussion."[1]

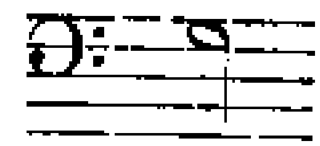
It was reserved for Helmholtz to solve the problem; and although the explanation may be found in the modern acoustical works already cited, it is necessary to state it here, reduced to as simple and practical a shape as possible.

The problem is, having given two musical sounds, of the same pitch and the same loudness, but of different character, to discover what is the physical cause of this difference? We know that the velocity and the amplitude of the vibrations are alike in the two cases, and therefore the cause must be sought in some other element of the sound-wave. The explanation, which is somewhat complicated, will be found in the following considerations.

There is a certain phenomenon very familiar to players on some kinds of musical instruments, namely, the production of what are called *Natural Harmonics.* Suppose, for example, a certain source of musical sound, such as the fourth string of a violoncello, or the column of air in the tube of a French horn, is set vibrating at the rate of 64 per second, so as to produce the note 

By certain means well known, it is easy to alter the mode of vibration, dividing the string or column of air into two parts, each of which will vibrate at double the former rate, viz., 128 vibrations, which will give a note an octave higher than before, namely,  This is called a *natural harmonic note* of the fundamental lower C. Again, similarly, the string or column of air may easily be made to divide itself into three equal parts, each of which will make $3 \times 64 = 192$ vibrations per second, and will

[1] In another place, however, Sir John hints clearly at the possible influence, on the quality, of the *form of the wave.*

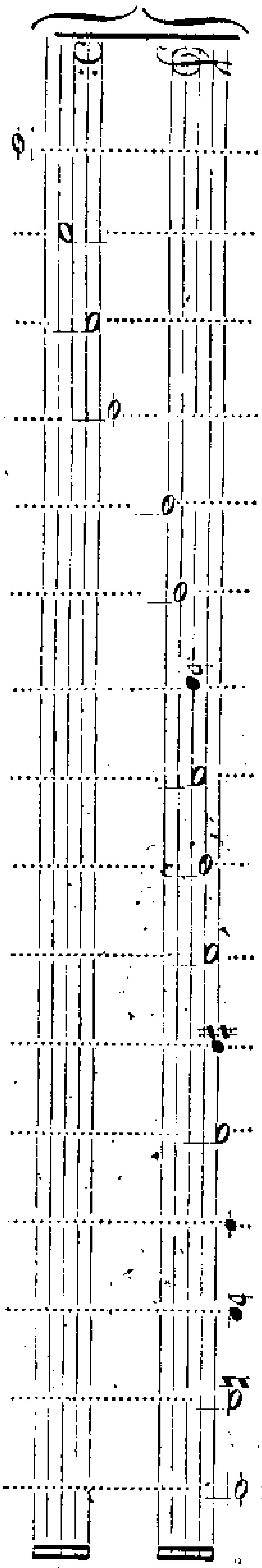
produce a second natural harmonic, namely,  It may further divide itself into four parts, each vibrating $4 \times 64 = 256$, and giving a third natural harmonic,  The division might be carried further, at pleasure, each harmonic note becoming higher in the scale. For example, the division into eight parts would give 512 vibrations, producing a seventh natural harmonic,  and the division into sixteen parts would produce a fifteenth natural harmonic, 

Now it has been discovered that these natural harmonics play a very important part in the constitution of musical sounds. It seldom happens that a musical sound consists of one simple note; it is generally a *compound*, formed of a fundamental note as a chief, *combined with a certain number of its natural harmonics* sounding along with it. The sounding body has a tendency to divide up into subsidiary parts, which *vibrate independently*, each producing the natural harmonic due to its rate of vibration, and the whole are heard together, forming the compound sound.

In such a sound, the natural harmonics above the fundamental have been called by Helmholtz *overtones* (Obertöne); and the whole series, including the fundamental, have been called *partial tones* (Parzialtöne), from the fact of the compound sound being made up of them. The latter term gives the most convenient numbering; but the former one is the most expressive, as distinguishing the subsidiary harmonics from the fundamental sound.

The harmonics or overtones have certain definite relations of pitch to each other and to the fundamental sound, these relations being as indicated in the following table.

TABLE OF NATURAL HARMONICS OR PARTIAL TONES.



Double Vibrations per Second.	
64	Fundamental Note, or 1st Partial Tone.
128	2d Partial Tone.
192	3d „ „
256	4th „ „
320	5th „ „
384	6th „ „
448	7th „ „
512	8th „ „
576	9th „ „
640	10th „ „
704	11th „ „
768	12th „ „
832	13th „ „
896	14th „ „
960	15th „ „
1024	16th „ „

The first harmonic will be an octave above the fundamental; the second a twelfth above it, the third two octaves above it, and so on. Some of the partial tones, namely, the 7th, 11th, 13th, and 14th, are inserted in a different character. The object of this distinction is to intimate that the places of these notes are not exactly expressed by their positions in the stave, as they do not correspond with the ordinary musical scale, and cannot therefore be expressed in the ordinary notation.

The figures below the table show the vibration-numbers corresponding to each partial tone, and it will be seen that every one is a multiple of the fundamental vibration number, corresponding to the position of the note in the series. Thus the 5th partial tone has five times as many vibrations per second as the fundamental; the 8th has eight times as many, and so on.

The table extends to the 16th partial tone; there is theoretically no limit to them, but this is probably as high as they can practically be identified. The lower ones are usually the loudest and most prominent, diminishing in strength as they ascend; the first six are the only ones that are usually considered to be of practical importance, and it is rarely possible to distinguish more than ten or twelve.

The phenomenon of these harmonics, as accompanying fundamental sounds, has been long known. Mersenne, the learned French writer, in his "Harmonie Universelle," published in 1636, says, speaking of a question of Aristotle—

"He seems to have been ignorant that every string produces five or more different sounds at the same instant, the strongest of which is called the natural sound of the string, and alone is accustomed to be taken notice of, for the others are so feeble that they are only perceptible by delicate ears. . . . Not only the octave and 15th, but also the 12th and major 17th, are always heard; and over and above these I have perceived the major 23d (the 9th partial tone) about the end of the natural sound."

Nothing was known at that day of the compound vibrations of strings, and hence Mersenne, having satisfied himself of the fact, endeavoured to explain it by an ingenious hypothesis about the motion of the air, which we now know to be unnecessary.

The same phenomenon was corroborated and better explained by subsequent writers; as Bernouilli, Riccati, and others. Rameau, in 1722, made it the chief basis of his system of harmony, as we shall see hereafter.

Chladni devotes much space to the explanation and description of compound sounds; and so widely spread was the knowledge of this phenomenon that he takes pains in many places to correct erroneous inferences that had been drawn from carrying its import too far. He shows that these sounds are not confined to strings, but may and do arise from organ pipes, wind instruments, and other sounding bodies, bells especially.

Young speaks of "the superior octave which usually accompanies every sound as a secondary note."

Sir John Herschel says (*Encycl. Metrop.*)—

"It was long known to musicians that, besides the principal or fundamental note of a string, an experienced ear could detect in its sound other notes related to this fundamental one by fixed laws of harmony, and which are called therefore harmonic sounds. They are the very same, which, by the production of distinct nodes, may be insulated, as it were, and cleared from the confusing effect of the co-existent sounds. They are, however, much more distinct in bells and other sounding bodies than in strings, in which only delicate ears can detect them."

Mr. Woolhouse, in an excellent little manual published in 1835,[1] after explaining the modes of vibration of a string first as a whole, and secondly as dividing itself into several equal parts, says—

"A string very seldom vibrates exclusively either to one or other of these modes of vibration, but generally partakes of both, and

[1] Essay on Musical Intervals, Harmonics, &c. By W. S. B. Woolhouse. London: Souter. 1835. P. 26.

often consists of several different modes all in action together. For when the string is vibrating wholly, and producing its fundamental note, it is generally subdivided into various portions, each of which is vibrating at the same time, and producing a harmonic. The mathematical theory of the motion of a musical string shows that any number of different kinds of vibrations, which can be communicated and sustained separately, may be communicated and sustained altogether at the same time ; and hence we see the reason why the fundamental notes of large strings, such as those of the harpsichord and violoncello, are usually accompanied with harmonic notes, which are more or less sensible, according to the strength or weakness of the vibral agitation of the portions into which the string has divided itself ; they are most readily communicated by a sudden action on the string near to one of its extremities, and therefore almost always accompany the tones of the pianoforte, particularly those of the bass."

It is desirable to collect these corroborative opinions on the point, because of the widespread scepticism that prevails among musicians as to the compound nature of musical sounds. There is great difficulty in getting practical men, who have not been accustomed to considerations of this nature, to admit that a note which, judging by the superficial impression on the senses, seems only simple and single, should really be compounded of a great many sounds differing much in pitch from each other, and some of them absolutely discordant. Helmholtz endeavours to combat this prejudice. He shows by several physical and physiological examples that the senses are apt, in the presence of prominent facts, to ignore others which may be *less* prominent but equally present; and he reasons that, as the fundamental note is almost always stronger than any of the others, the imagination is inclined to refer the whole combination to that one note, and refuses to take the trouble of recognising the separate sounds.

An analogous case is that of a large organ: the sounds from the separate pipes are in themselves but weak, and no multiplication of them, in unison, would give tones of great power. Hence the long experience of organ-b

note pipes speaking its octave, twelfth, fifteenth, and other of the harmonics we have described, the effect of which is, as is well known, to produce tones of a most powerful and penetrating quality. Yet, if these harmonics are well proportioned, they give to an ordinary ear only the effect of one single loud sound.

By a little practice the ear may be educated to distinguish and separate the various harmonics which make up a compound sound, and when the habit of doing this is acquired, the illusion disappears. But that no proof may be wanting, Helmholtz has contrived mechanical means by which any sound may be analysed, and its component parts exhibited separately. He uses certain instruments called "resonators," each of which, like a chemical re-agent, will test the presence of a particular harmonic, and by submitting these in succession to the vibrating influence of the compound tone, they at once show whether the sounds they refer to are or are not present therein.

It has been necessary to describe the compound nature of musical sounds at some length, because of its bearing on the point now under consideration, namely, the explanation of the varying *character* of musical tones.

Chladni appears to have had some suspicion that the variations in the character of the vibrations had some slight influence on the quality,[1] and Mr. Woolhouse[2] attached more importance to the same element. But in reality nothing was positively known about the matter before the investigations of Helmholtz. It was reserved for him to show, by the most elaborate and conclusive proofs, that *the character of a musical sound depends chiefly on the number and on the proportionate strength of the partial tones of which the sound is composed.*

[1] Die Verschiedenheit der Schwingungsarten trägt meistens nur wenig zu einer verschiedenen Wirkung des Klanges bei. Page 48.

[2] Essay, cited. Page 77.

Referring again to the diagram on page 40, there may, in the first place, be great variety in the number of partial tones present. In some cases there may be only a few of the lower ones; in others the overtones may be very numerous, extending very high; and in other cases certain intermediate members of the series may be absent. Every variety of this kind will give a different quality of tone.

Then there is the second element of the proportionate strength or loudness of the various partial tones. The fundamental note is almost always the most powerful, and, generally speaking, the strength goes on diminishing fast as the overtones ascend. But the degree of gradation in different cases is very variable, and every variation influences the quality of the tone.

It is then to the combination of these two varying elements, the number present, and the relative loudness of the harmonics, that the *character of tone* of a musical sound is due.

There are very few natural sounds which consist of the fundamental note only. The nearest approach to simple sounds are the tones of the larger stopped wood pipes of an organ. The soft notes of an old-fashioned flute are also somewhat of this nature, though the modern attempts to give brilliancy to this instrument have in great measure altered its original character. The vowel sound, *u* (Italian, or *oo*, English) is also weak in overtones. Tuning-forks have sharp overtones when first struck, but these soon die away, and the prolonged sound is tolerably simple.

These instances will give some idea what simple tones are like. They are soft, dull, and monotonous, and entirely devoid of shrillness or brilliancy; and it is a curious characteristic of them that they often give the impression of being lower in pitch than they really are.

On the other hand, the addition of overtones gives life, richness, brilliancy, and variety to the sounds, and raises the impression of pitch. In proportion as the

higher tones predominate, so will the sound be brighter and sharper, or if in great excess, more metallic and thin; but in proportion as they are weak, allowing the fundamental and lower harmonics to predominate, so will the sound be more full, mellow, and sombre, approaching thereby more closely to the character of the simple tone.

All the qualities of tone most valued and most useful in music are rich in harmonics, as will be seen when the tones of musical instruments come to be analysed.

When a discovery has been made of the constitution of a compound body, by analysing it into its constituent elements, the efforts of science are naturally turned to the converse process of proving the same proposition by *synthesis*, or by combining the single elements and showing that they will produce the compound. This proof is not wanting in the present case; allusion has already been made (page 43) to the organ, which shows a direct practical construction of a single powerful musical sound by building up its constituent partial tones. But other examples of the same process have been devised. Helmholtz has succeeded in combining simple sounds together in such a way as to produce imitations, not only of the vowel sounds, but of other peculiar qualities of tone; not perfectly, from the extreme difficulty of imitating exactly all the minute shades of difference that enter into the combination, but still with sufficient success to demonstrate the general argument.

We are now in a position to identify the third practical property of musical sounds with the third feature of elastic vibrations and the corresponding property of sound-waves.

The several partial tones which constitute a compound sound result from a combination of subsidiary vibrations with the chief or fundamental one; these combine into a single vibration of very complex form, and thus the

character of the sound is identified with the *form of the vibration;* and consequently as the form of the vibration determines the varieties of arrangement of the compression and expansion in the air, this again is identified with the *form* of the *transmitting air-wave.*

The form of the vibration, affected by all these subsidiary harmonic oscillations, must become very complicated, and the transmission of all these motions by one sound-wave of the air must involve more remarkable complications still. Yet intricate as the process may be, there is no doubt that the human ear has the wonderful faculty of analysing in a moment the almost infinitely complicated form of the wave, and of deducing from it a distinct series of separate simultaneous impressions exactly corresponding to the separate vibrational impulses from which it was originally derived.

This is the great discovery of Helmholtz. In its complete form it is entirely new; it solves a problem of the greatest interest; the demonstration is most conclusive and admirable, and we are justified in pronouncing it perhaps the greatest advance in musical acoustics that has been made since the study of sound assumed a scientific form.

But the doctrine of the compound nature of musical sounds is not only applicable in explaining their quality; it has many very important bearings on the structure of music; and, in fact, it forms the foundation for almost the entire philosophy of the art, so far as this can be referred to natural phenomena. This point it will be the object of future chapters to show.

CHAPTER IV.

THE THEORETICAL NATURE OF THE SOUNDS OF MUSICAL INSTRUMENTS.

HAVING discussed musical sounds generally, it is proposed in this chapter to add some considerations on the theoretical nature and mode of production of the sounds of musical instruments of various kinds.

This subject also lies within the domain of acoustics, and therefore need only be here noticed briefly, referring to the acoustical works for more full information.

The sounds of musical instruments are produced on several different principles, namely—

By the *vibration of stretched strings*, as in the pianoforte and violin.

By the *vibration of reeds*, as in the harmonium, clarionet, and the reed stops of an organ.

By the *vibration of elastic membranes acted on by air*, as in the trumpet and horn tribe, and in the human voice.

By the *vibration of elastic membranes struck with a solid body*, as in the drum.

By the *vibration of elastic solid bodies*, as in tuning-forks and bells.

By the production of *vibrations directly in the air itself*, as in the common whistle, the flute, and the general pipes of an organ.

Instruments with stretched strings.

Stretched strings form the foundation of some of the

usical instruments, and the sounds are
m in several different ways.

ıy be *plucked*, with the hand as in the
or with a plectrum as in the harpsichord
struments.

;s may be *struck with a hammer*, a plan
ied in our familiar pianoforte, furnishes,
tenths of the music of the present day.

, the strings may be excited with a *bow*, as in the great ...nily of instruments, of such wonderful capability, represented by the violin.

The use of strings for musical purposes is of great antiquity; probably, in the earliest records we have of instrumental music, this mode of producing it appears. It has, however, a more especial historical interest, because stretched strings furnished, in the hands of Pythagoras, five or six hundred years before the Christian era, the first means of *giving exactitude to the principles of music.*

Before his time, so far as we know, there was no mode of identifying sounds, or expressing their relations to each other, except by the guidance of the ear. And it was next to impossible, in this state of things, to reduce music to any satisfactory system. He had, however, the genius to find out that, by means of the properties of stretched strings, sounds might be absolutely and positively identified, and their relations accurately compared and studied; and he thus brought music for the first time within the range of mathematical calculation.

It will be interesting to notice the principles on which he proceeded; and we have a great advantage in doing this, inasmuch as we now know the real physical cause of the sounds, and can reason on the number of their vibrations, an element of the question unknown in Pythagoras's day.

The most important inquiry as to . is, What is the *pitch* of the note it will :

This is influenced by three qualities possesses, namely—

1. The weight.
2. The tension.
3. The length.[1]

First as to the *weight* of the string. In pro, string is thicker, or *heavier*, it will, on mec. ...al principles, vibrate more slowly, and consequently it will speak a *lower note.* A glance inside a pianoforte will show that the strings increase in thickness and weight as they descend in pitch; and the lowest of all are usually lapped with wire twisted spirally round them, to give them sufficient weight to produce the grave tone. The lower strings of the violin and violoncello are also lapped with silver wire for the same reason.

The rapidity of the vibrations is proportionate, *inversely*, to the *square root of the weight* of the string:—for example, if it is found that a pianoforte wire of a certain length and tension, and weighing 40 grains per foot, makes 256 vibrations per second, sounding the note  by substituting a wire of one-fourth the weight or 10 grains per foot, keeping the tension the same, we shall find it makes 512 vibrations per second, and will consequently sound the note .

[1] The principles of stretched strings may be well and easily studied practically by means of a very useful instrument called a *monochord*, It is simply an arrangement for stretching a wire so that its various elements of length, tension, &c., can be easily adjusted at pleasure, and their effect on the note sounded thereby demonstrated. Every student of the subject should make himself practically familiar with this excellent contrivance; it is of great use in many other ways for the study of musical theory, on account of the facility with which, by adjusting the length of the string, definite and very small differences of pitch may be obtained.

The second element is the *tension* of the string. The *tighter* the string is stretched, the more rapidly will it vibrate, and the *higher* or more acute will be the sound. This is the foundation of the familiar principle of *tuning* all stringed instruments; which consists merely of altering the tension of the strings, in order to bring them to sound the note desired. The tension on a pianoforte string varies from 100 to 260 lbs.; on the whole of a large grand piano it reaches as much as 16 or 17 tons.

The rapidity of vibration varies *directly as the square root* of the tension. Thus if a wire be stretched with a tensile force of 25 lbs., by increasing this to 100 lbs. the vibration-number will be doubled, and the string made to speak an octave higher.

The third element is the *length* of the string. With the same string, stretched under the same tension, the rapidity of vibration is exactly *in inverse proportion to the vibrating length* of the string. Doubling the length will give half the number of vibrations per second, and will produce a note an octave lower. Halving the length of the string will give twice the number of vibrations, and will produce a note an octave higher.

Hence all gradations of pitch can be produced by stopping off the string to such a length as is suitable to the note required. This is the principle of violin-playing, and it is this that gives to that class of instruments their exquisite perfection of intonation; seeing that the performer can adjust the length with the greatest accuracy.

This fact, namely, that the note sounded by a string may be defined by its proportionate length, was the great discovery of Pythagoras; and it will be seen, in a future chapter, the important use he made of it in settling the music of the Greeks on a basis intelligible for all future time.

Taking the three elements of a stretched string all into calculation together, it is possible to determine, by mathe-

matical reasoning, what note any string ought to sound. Or in other words, having a string of a given weight and length, and stretched with a given tension, we may calculate, on unerring mathematical principles, what number of vibrations it ought to make in a second of time.[1]

Hence, since we can try by experiment what note such a string will sound, we have a means of determining what musical note corresponds to a certain given *vibration number*, and conversely, what number of vibrations corresponds to any given note.

But stretched strings are very useful in regard to another important point of modern musical theory; namely, as furnishing one of the simplest and most appropriate illustrations of the compound nature of musical sounds, as described in the last chapter.

The diagram on following page will aid in the explanation of this point.

[1] The formula for doing this was first worked out in 1715 by Dr. Brook Taylor, the learned mathematician and author of the celebrated "Methodus Incrementorum," and it is as follows:—

Let. W = whole weight of string.
T = tension.
l = length of string.
L = length of a pendulum vibrating seconds:—

$$\left.\begin{matrix}\text{Dble. Vib.}\\ \text{per Sec.}\end{matrix}\right\} = \frac{\pi}{2}\sqrt{\frac{T}{W}\times\frac{L}{l}}$$

Or it may be put in a more practical form, thus:—

Assuming L, in the latitude of London, = 39.126 inches; make w = weight of the string per inch of its length; and l = length in inches, T and w being both taken in the same unit.

$$\left.\begin{matrix}\text{Dble. Vib.}\\ \text{per Sec.}\end{matrix}\right\} = \frac{9.825}{l}\sqrt{\frac{T}{w}}$$

Or, for arithmetical calculation, multiply the tension in lbs. by 84,000, divide by the weight in grains of a foot-length of the string, and take the square root of the quotient. Multiply this by 9.825, and divide by the length of the string in inches. The result will be the number of double vibrations per second.

DIAGRAM TO ILLUSTRATE THE COMPOUND VIBRATIONS OF STRINGS.

IV.

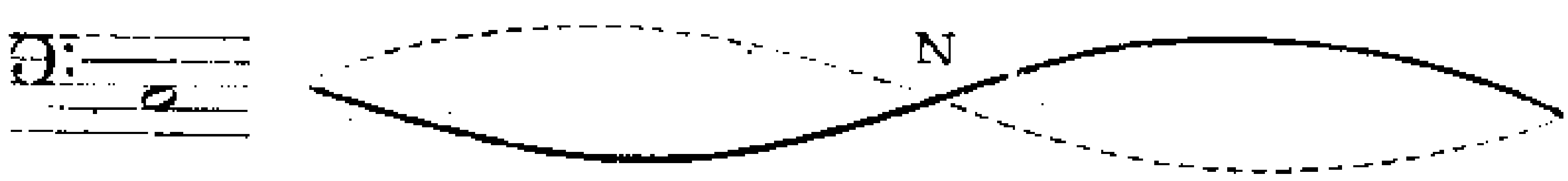
Fourth Partial Tone, 256 Vibrations.

III.

Third Partial Tone, 192 Vibrations.

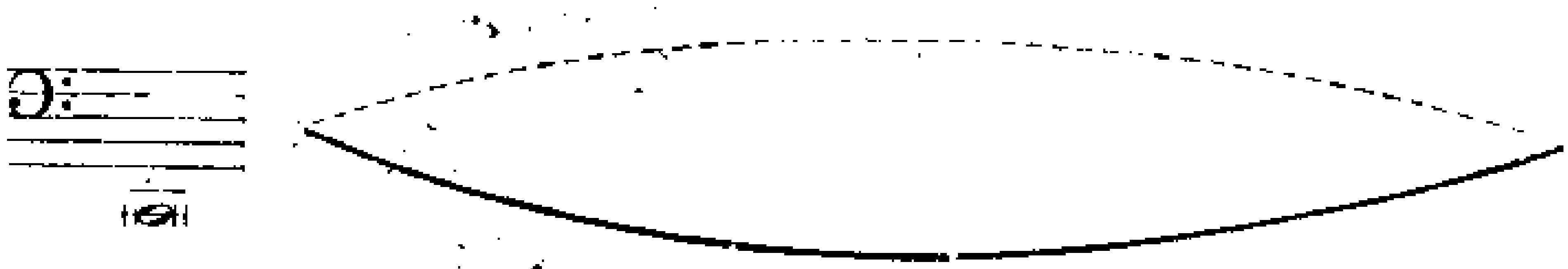
II.

Second Partial Tone, 128 Vibrations.



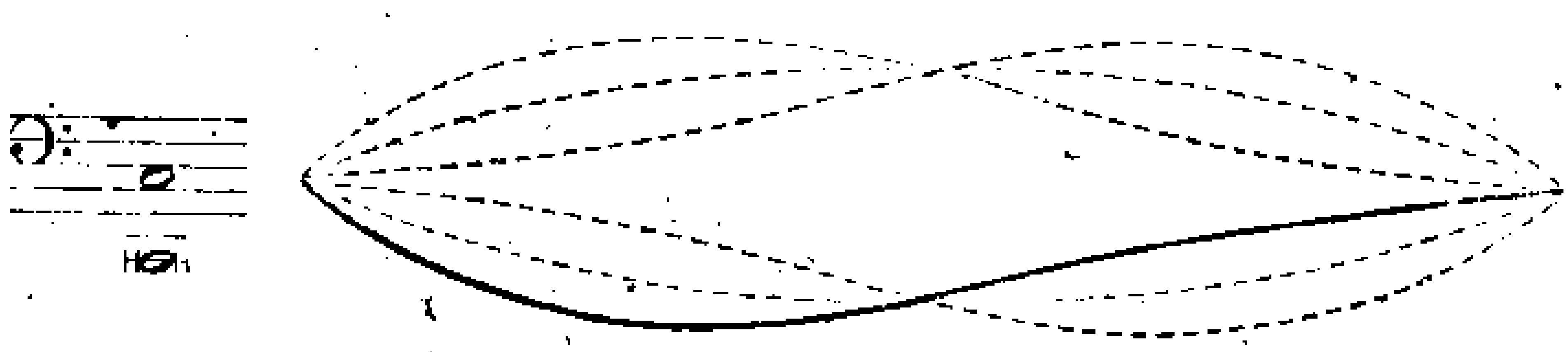
I.

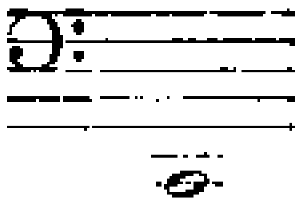
Fundamental Note, or First Partial Tone, 64 Vibrations.



I. and II.

Combination of First and Second Partial Tones.



Suppose a string of such length, thickness, and tension, that when it is set sounding it will vibrate 64 times in a second, giving the note 

This simple vibration of the string as a whole may be represented by the figure marked I.

If one could prevent any other kind of vibration from being set up, the sound would be a *simple* one, giving the fundamental note alone. But this would be difficult, for the string has a natural tendency to take upon itself other motions, and thereby complicate the effect produced. In the first place it will divide its length into two equal parts, and each of these halves will set up a vibration of its own, as represented in the figure II., with what is called a *node* or point of rest in the middle of the string. And as, by a well-known mathematical law, each vibration of the half string will take place in half the time of the main or fundamental one of the whole string, we shall get an additional note due to 128 vibrations per second, forming the first *harmonic*, or second *partial tone*, an octave higher. But further, the string may also divide itself into *three* equal parts, by two nodes as in figure III., and each of these parts will vibrate separately in one-third the time of the fundamental vibration, giving the third partial tone a twelfth above the fundamental. Similarly the string may further divide itself into four, five, six, and a still greater number of parts, each of which will form a perfect vibration of itself, producing its corresponding harmonic or partial tone. Only the four first are shown on the diagram, but these are sufficient to illustrate the principle. The various nodes are marked with the letter N.

Now when a string is struck or bowed, it will not only vibrate as a whole, but a number of these subsidiary vibrations will be excited *at the same time*, and all will go on simultaneously. It would be hardly practicable to repre-

sent graphically the result of all these combined vibrations; but the lower figure of the diagram is intended to show the combination of the two simplest, *i.e.*, the fundamental note and its octave.

We have only then to imagine a certain number of these vibrations to be combined, varying in strength in the proper way, and we get at once an intelligible and simple idea of the nature and mode of production of a *compound sound*.

And it may be added that this is not mere speculation. Ingenious modes have been applied for rendering appreciable the motions of vibrating strings, and the compound vibrations above described have been actually observed and recorded.

The string gives the simplest example of the mode of generation of a compound sound; but the compound wave of the air may be equally well produced by other means, such as a reed, or may originate in the air itself, as in an organ pipe. In most cases where a fundamental note is formed, there is the same tendency for it to be accompanied by subsidiary fractional vibrations, producing corresponding overtones.

The character of string-tones varies considerably, according to the manner in which the sound is produced.

When a single impulse is given, either by striking, as in a pianoforte, or by plucking, as in a harp, the number and strength of the overtones depend chiefly on the nature of the impulse, the place where it is applied, and the thickness, stiffness, and elasticity of the string. Helmholtz discusses fully all these points; but it will suffice here to give only a few illustrations of them. When a string is pulled with a narrow point, or struck with a narrow, hard hammer, so that only a small portion of the string is acted on, theory shows that the higher subsidiary vibrations ought to be more numerous and powerful than when the string is pulled with the soft, broad finger, or struck with

a broad, soft hammer; and hence the tone in the first case will be thin and metallic, in the latter full and mellow. The construction of pianoforte hammers arrived at by long experience, is precisely such as, according to this theory, it ought to be, to produce the best tone.

The place where the string is struck is very important, for the mechanical reason, that no harmonic tone can be produced which has its node at or very near the point struck, and that those harmonics are the strongest which have the striking point midway between their nodes. This accounts for the fact that the striking point has always been a subject of the most careful practical study by the best pianoforte makers, leading to a remarkable coincidence with theory, although the theory was unknown. The point now adopted is generally at one-seventh to one-ninth the length of the string, and this has the effect of excluding from the series the seventh and ninth harmonics, which, as will be seen by the diagram on page 40, are the first which are inharmonious to the chord of the fundamental note, and which if they were allowed to be powerfully present would interfere with the purity and beauty of the tone.

The first six partial tones are all audible in a good piano; the three first strong, the fifth and sixth weaker, but still clear; the seventh and ninth, bad ones, are excluded, as is also the eighth, a good one (but this can well be spared as it is merely the octave of three lower ones), and all above are too weak to do any mischief. Helmholtz has given a table of the comparative strength of the six first partial tones, as produced with hammers of different kinds. With a perfectly hard hammer they are 100, 325, 500, 500, 325, 100 respectively; with a medium one, 100, 249, 243, 119, 26, and 1; and with a very soft one, 100, 100, 9, 2, 1, and 0. These figures are obtained purely by mathematical calculation, and they agree generally with the facts observed.

degree the production of the harmonics; thin and flexible strings will vibrate in short lengths much more easily than thicker and stiffer ones, and will be more liable to produce the higher overtones. And hence the well-known empty metallic jangling sound of thin wires. This is one reason why the thicker strings used in modern pianos allow of a more powerful blow, without the production of the high and unfavourable tones that would inevitably result from such a powerful impulse applied to a thin string.

The vibrations of strings excited with the bow do not admit of mathematical determination beforehand, as it is impossible to define accurately what the action of the bow will be in imparting the motion. But by an exceedingly ingenious contrivance, Helmholtz has succeeded in applying the reverse process, by rendering the actual vibrations of a violin string visible; and by an equally ingenious train of mathematical reasoning he has been able to analyse the complicated motions it exhibits, and to resolve them into their original harmonic elements. The general result is as follows.

All the harmonics are present which the stiffness of the string will allow, and they are easily heard. As a general rule, they diminish gradually in strength upwards, in inverse proportion to the square of their ordinal numbers. When the vibrations are perfectly regular, the tone is very pure and agreeable; but the strings are liable to irregularities and interruptions in the vibration, not only from unskilful bowing, but also from imperfect elasticity in the material of the violin, inasmuch as the sound is propagated through the air, not so much from the string itself as by the resonance of the wood body. The great difference in the quality of tone of instruments by different makers is due to this cause, and the improvement of violins by use and by age is accounted for by their beneficial influence on the elasticity of the wood. Hence

also the superiority of the tone produced, even on an indifferent violin, by a good player, who can so command the action of his bow as to produce the utmost regularity of which the instrument is capable. These are not now mere speculations, as heretofore; they are positive physical phenomena, which have been demonstrated by careful observation.

There is an element in stringed instruments, in addition to the strings, which is of such importance as to deserve notice, namely, the *sound-board.* Although the strings are the source of the sound, their tone would be very thin and poor if used alone; it is modified, amplified, and improved in quality by the vibrations being communicated to a much larger resounding body.

In the violin tribe the whole body of the instrument acts as a sounding-board. The vibrations are communicated from the strings to the bridge, and from the bridge to the body, which then sets up vibrations of its own, corresponding in *rapidity* to those of the strings, but altered in amplitude and form, and it is these vibrations which are transmitted most prominently to the ear.

In the pianoforte the sounding-board is a sheet of thin firwood placed immediately under the strings, and communicating with them by bridges, as in the violin. The wires give the note; but for the power and quality of tone the sounding-board is responsible. This is a more remarkable case than the violin, on account of the number of different sounds that are given off together. The same board appears, at one and the same time, to form part of any number of systems of vibration, and to vibrate in unison with every note of a chord. Thus any number of notes struck at once will distinctly impress the ear; and as it is certain that every note must have a distinct and separate set of compound vibrations in the sound-board peculiarly belonging to itself, the mind becomes bewildered in trying to imagine the immensely complicated motions

that must be going on in that simple-looking sheet of Swiss pine.

Instruments with Reeds.

In another class of musical instruments the tone is produced by the vibration of what is called a reed, *i.e.*, a thin tongue of some elastic substance, which is placed in or upon an opening through which air passes. The current sets the reed in vibration, by which the aperture is alternately opened and closed with great rapidity, the effect being to divide the current up into a series of puffs, each communicating a distinct impulse to the air, and the whole combining into the succession of vibrations producing the sound.

The simplest applications of this principle are in the harmonium, concertina, and accordion, where the reed may easily be seen. The oboe, clarionet, and bassoon, and what are called the reed stops of an organ, owe their tones also to reeds, similar in principle, but of varied forms of construction; and in them the air, issuing from the reed opening, is allowed to pass through pipes of various forms, in which the vibrations receive additional strength and other modifications, and the sound produced acquires greater power and variety.

Under this kind of interrupted impulse, the tendency to form overtones is at a maximum, and observation proves that the sounds of these reeds contain a long series of harmonics up to the sixteenth, or even higher, which produce the peculiar sharp cutting quality characteristic of them. The number and strength of the overtones will depend on the more or less yielding quality of the reed, and when this is such as to give the dissonant higher tones material strength, the quality becomes harsh and disagreeable. In the tones of the harmonium the partials with odd numbers are generally the most predominant.

In organ reed stops the effect of the added pipe is

to strengthen those harmonics which correspond to the vibration of the column of air in the pipe, and so to modify and improve the tone.

In the organ and allied instruments each note has a separate and independent reed, and the *pitch* of the note sounded depends on the length and weight of the vibrating tongue.

But in the clarionet, oboe, and bassoon, one reed is made to serve for the whole scale of the instrument, sounding perhaps thirty or forty different notes. It is made of very light flexible wood, and is so sensitive that its velocity of vibration is capable of instantaneous alteration in sympathy with that of the vibrating column of air in the pipe; so that when this column is lengthened or shortened by the closing or opening of holes in the side of the tube, the reed and the air both change simultaneously their velocity of vibration.

The clarionet has a cylindrical pipe, which has the effect of strengthening only the partial tones with odd numbers, namely, the 1st, 3d, 5th, and so on distinctly audible up to the 7th. The tubes of the oboe and bassoon, which are conical, strengthen all up to a certain height, but not higher, so as to do away with the disagreeable effect of the high dissonant sounds.

Instruments sounding by the action of elastic membranes on a current of air.

Another mode of sound production, somewhat analogous to the last named, is by the action, on a current of air, of elastic membranes.

The human lips afford the most common example of this. When they are pressed into the mouthpiece of a trumpet, for instance, and air is blown through them, in a particular way, they fall into vibrations, and communicate their vibrations to the column of air entering the tube of the instrument. The vibrations are modified by

ence is sent back to the lips, so that the periods of the two correspond.

The horn, trombone, cornet-à-piston, and bugle are all on this principle; and in order to get an air column sufficiently long to vibrate certain notes, and still to keep the instruments portable, the length is usually disposed in spirals or other curvilinear forms. The notes are varied by causing the vibration of different harmonic fractions of the air column, a process naturally carried out by the sensitiveness of the lips; and intermediate variations are made by altering the length of the column by valves or slides, or by introducing the hand into the bell of the tube.

The vibrations in these instruments are very powerful, and contain, like the reed sounds, a large series of overtones, which, though they are to some extent modified, in their higher extent, by the tubes, suffice to give great shrillness and brilliancy to the tone.

The phenomena of wind instruments have not been so perfectly investigated as those of strings, but sufficient has been said to show the general applicability of the theory.

The human voice is an instrument of the same kind, the vibrations being produced by the elastic vocal chords of the larynx, and modified by resonance in the cavities of the throat and mouth. It has the advantage over all artificial instruments in the great facility and precision with which the variable elements can be adjusted so as to produce almost infinite diversities in the pitch, the loudness, and the quality of the sound. The pitch depends on the tension of the vocal chords, determining the velocity of their vibration; and the loudness on the energy of the oscillations given to the passing air; but the quality of the tone appears to depend chiefly on the resonance of the air passages.

In regard to this latter point we may refer to those

more marked differences in quality produced in one and the same voice by the varieties of *vowel sounds.* The consonants are mere accidental mechanical effects accompanying the emission of the voice, but the vowel sounds are clearly variations in the *timbre* of the voice itself.

The investigation of this interesting subject has long occupied physicists, among whom our own countrymen Wheatstone and Willis deserve honourable mention. Helmholtz has completed the explanation and brought it within the range of his general theory.

The sound issuing from the larynx is produced under circumstances the most favourable possible for the production of overtones, and experiment shows them to be plentifully present. In a powerful, clear bass voice the harmonics can be clearly heard, by the aid of resonators, up to the sixteenth or the fourth octave above the fundamental; and in forced notes harmonics may be produced reaching up to nearly the highest notes of a modern pianoforte.

The strength of the overtones, particularly of the higher ones, is subject to much variation in voices of different quality; being more powerful in clear and sharp voices than in weak and dull ones. The great differences in quality that are found, by everyday observation, to exist between different voices may lie partly in this, and partly in other anatomical and physiological variations of structure and action that are difficult to describe, although Helmholtz makes an attempt at the description. If we could hear the tone of the larynx alone, unaffected by the resonance of the air passages, we should probably find that the loudness of the harmonic tones diminished gradually and evenly upwards, like those from any other reed; and in some vowels, such as the German *ä*, in which the mouth assumes a funnel shape, this is tolerably near the actual effect.

In the majority of cases, however, the strength of the

overtones is much varied by modifications in the form and contents of the air spaces; for in proportion as these are altered, either by the lips, the jaws, or the tongue, so the resonance is made to correspond with special notes; the consequence of which is to strengthen the overtones which approach nearest to these, and to damp the others. By experiments with resonators the first six or eight overtones are always found present, but in greatly varied strength according to the position of the mouth, sometimes piercingly sharp in the ear, sometimes scarcely perceptible.

We cannot follow Helmholtz into the elaborate detailed investigation he has made of this subject; it must suffice to say that he has perfectly identified the vowel sounds with the musical notes corresponding thereto. He finds these constant in all persons, irrespective of sex or age, and suggests that they will furnish to philologists a means, which has long been wanting, of defining with physical accuracy all the nice shades of distinction in the vowel sounds of different languages or varieties of speech.

The varieties of vocal sounds differ essentially in their constitution from those of artificial instruments, inasmuch as in the latter, for a certain quality we suppose that the arrangement of strength of overtones bears always the same relation to the fundamental, whatever this may be; whereas, in the voice the peculiar quality producing vowel sounds depends on the strengthening of certain *fixed notes* of the scale, or some very near them, independent altogether of the pitch of the fundamental.

A curious illustration of the mechanical formation of vowel sounds is furnished by the experiment, that if we sing into an open pianoforte, with the dampers elevated, one of the Italian vowels, the same vowel sound will be returned and prolonged by the instrument, showing that it depends on vibrations spontaneously imitated by the strings.

To show that the theory of the formation of vowel

sounds is correct, Helmholtz has succeeded in producing them artificially, by combining the different partial tones of which he asserts they are composed. The operation is a very difficult and delicate one, but it has succeeded well enough to substantiate the proof of the theory.[1]

Instruments producing their sounds by percussion of stretched membranes.

The most familiar representative of this class is the drum, in which a stretched disk of elastic parchment is struck with a stick. In the big-drum and side-drum no musical note is aimed at; but in the kettle-drum, used in the orchestra, the parchment can, by screws on the circumference, be given different degrees of tension, which, on the principle explained for strings, will give different degrees of pitch. In this drum also the membrane is stretched over a hollow cavity, which acts as a resounding chamber, and considerably improves the tone.

Instruments depending on the percussion of solid bodies.

The chief instruments of this class are tuning forks, triangles, cymbals, glass and wood harmonicas, and bells.

Most of these have a peculiarity in regard to their overtones. In the cases hitherto described, all the partial-tones have been supposed to correspond with the regular harmonics due to simple multiples of the vibrations of the fundamental. But there are some cases in which the nature or conformation of the vibrating body is such as to give rise to what may be called irregular overtones, having inharmonic relations to the fundamental. For example, the first overtone of a tuning fork gives an undefined variable note, vibrating somewhere between 5.8 and 6.6 times as fast as the fundamental, and the others are equally inharmonic.

[1] Some valuable investigations on vowel sounds have been published by Professor Fleeming Jenkin in the Transactions of the Royal Society of Edinburgh, and by Messrs. Preece and Stroh in the Proceedings of the Royal Society of London.

The subsidiary tones thus produced are called *inharmonic* overtones; and the compound sounds which contain them lose, in proportion as they prevail, the satisfactory character of musical tones normally constituted: for which reason their use in music can only be tolerated when the fundamental largely predominates, and even then only with certain precautions.

Not only tuning forks, but elastic bars in general, also flat elastic plates (whose properties were so curiously illustrated by Chladni), and stretched membranes, have this peculiarity. Bells also give overtones, many of which are inharmonic, and which vary according to the make of the bell, so that part of the skill of the founder lies in so proportioning the bell as to produce the least unmusical effects from this cause. If the form of the bell is not quite symmetrical, one part being thicker or heavier than another, two notes a little out of tune with each other are produced. By striking certain parts of the bell, either of these notes is sounded; by striking other parts both sound together, which causes the *beats* so often heard when the sound of a bell is dying away.

Skilful players have often attempted to perform upon bells not only changes and melodies (as in the chimes and carillons so common in Belgium and Holland), but also music in harmony; but the effect on the latter of the inharmonic overtones is so powerful as to render such music almost unendurable—a result which, though practically long known, has never before been satisfactorily accounted for.

Instruments in which the origin of the sound is in the air itself.

In all the cases treated of hitherto, the sound has had its origin in some vibrating body, the vibrations being communicated from it to the air. But musical sounds may also be produced by setting up vibrations in the

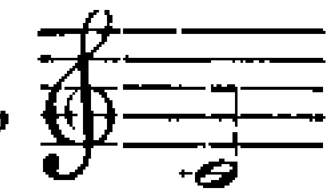
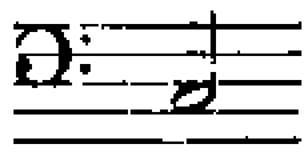
air itself, without the aid of any original vibrating body.

The most simple example of this is the common whistle. A thin flat current of air is caused to impinge on a sharp knife edge, which cuts it in two, the effect being to set up a sort of fluttering or beating action, and so to put the air in regular vibration, producing a musical note. In most cases this apparatus forms the foot of a pipe, and the sharp cutting edge is so placed that part of the air enters the tube, setting the whole column it contains into vibration, and so producing a powerful tone. The tube may be either closed or open at the top, and may have other modifications, all influencing the sound.

On this principle are constructed all the pipes of an organ, except the reed-stops before-mentioned. The German flute and the flageolet also belong to the same class. Taking an organ-pipe as the best example, the pitch depends on the length of the vibrating column of air, which is determined by the length of the tube, and whether the top is open or stopped.

With an open pipe it is found that the length of the sound-wave produced will be double the length of the pipe; and hence, assuming the velocity of sound to be 1100 feet per second, if a pipe be l feet long the length of the sound-wave will be = twice l, and the pipe ought to produce a note vibrating $\frac{1100}{2l}$ times per second. Or conversely, if v = the number of vibrations per second corresponding to any given note, the length of the pipe in feet should be $= \frac{550}{v}$.

Take, for example, the note  which corresponds to 512 vibrations; the length of an open organ-pipe

rule is somewhat modified by the diameter of the pipe;[1] but it is a fact that the pipe corresponding to this note is about one foot long. For the C below,  having 256 vibrations, the pipe will be about two feet long; for  of 128 vibrations it will be four feet long, and so on, doubling for every octave the note descends. Now, as C is considered the most important note of an organ, the different octaves of this note have acquired, in organ nomenclature, the names of one-foot C, two-foot C, four-foot C, and so on, down to 16-foot C, which is the lowest note in ordinary organs, and 32-foot C, which is the lowest in very large ones.

If the pipe is *stopped* at the top, the effect is to make the length of the sound-wave four times the length of the pipe, or, in other words, to make a stopped pipe speak an octave lower than an open one, the theoretical length of the pipe, measured up to the stopper, being $\frac{275}{v}$.

In the German flute the pitch depends on the effective length of the tube, which is varied by opening and closing holes in its side.

The tone of these instruments is often modified by the addition of the rushing noise caused by the wind; but the same laws in regard to the production and effect of overtones apply as in all other cases of musical sounds.

Wide stopped pipes, on account of peculiar relations of the mass of air in vibration, give their fundamental note

[1] Mr. Ellis ("Nature," p. 172, 26th December 1878) has shown that the influence of the diameter on the pitch of open organ-pipes may be expressed by the following formula: Let L = length from lower lip to open end; and D = internal diameter; both in inches. Then, at 60° Fahr.,

$$\text{Double vibrations per second} = \frac{20080}{3\,L + 5\,D}$$

$$\text{or } L = \frac{6693}{v} - \frac{5}{3}D.$$

This shows that increasing the diameter (which gives a more powerful tone) slightly diminishes the length necessary to produce a given note.

almost pure, with but little accompaniment of overtones; but narrower ones have the addition of the third partial tone or twelfth, an effect well known in what is called the "stopped diapason" register of the organ. In modified forms the fifth partial tone may also be heard; but the partial tones with even numbers, representing the octave, double octave, &c., are absent.

This peculiarity of stopped pipes, and their general deficiency in overtones, gives them a dull, weak, hollow quality of tone, especially in the bass, which contrasts remarkably with that of the open pipes, the latter being much clearer and more brilliant from their greater richness in overtones.

In narrow, open pipes, such as those of the organ stops called the violone, viola di gamba, &c., the fundamental notes are weak, and are accompanied by a series of strong overtones (often audible up to the fifth) which give a thin tone, somewhat imitating the stringed instruments from which they take their name. In the larger open pipes the fundamental tone is stronger, and the overtones are less prominent; and these are consequently the most useful pipes in the organ. In open wood-pipes Helmholtz found only the second partial tone prominent, the third weak, and the higher ones inappreciable. In metal ones the fourth was also audible. The well-known difference in quality between pipes of wood and metal is partly owing to this, and partly to the fact that the wood surfaces do not resist the vibrations so well as the metal ones, whereby the higher tones appear to be more readily extinguished by friction.

The peculiar qualities due to special forms of organ pipes are due to exceptional arrangements of the harmonics produced thereby; for example, in pipes with a conically diminished top, the fifth to seventh partials are especially prominent, giving a thin but clear and characteristic tone.

PART SECOND.

ELEMENTARY ARRANGEMENTS OF THE MATERIAL.

CHAPTER V.

THE GENERAL ARRANGEMENT OF MUSICAL SOUNDS BY STEPS OR DEGREES.

Now that we have formed some philosophical idea of the nature of the material of music, we go on to consider the way in which this material is made use of.

Music finds, as Helmholtz remarks, an infinitely rich but totally amorphous plastic material in musical tones, which may be shaped into form, unfettered by any of the restrictions that apply to other of the fine arts. Painting and sculpture, for example, are fettered by the necessity for imitating nature; poetry must conform to the existing symbolical meaning of sounds; architecture must consult utility of construction; but music is absolutely free to dispose of her material in any way whatever, which the artist may deem most suitable for his purpose.

Hence it is exceedingly interesting to trace in what way this artistic work has been carried out; and it seems desirable, before going into the complex structure of music, to investigate what we may call the *elementary arrangements of the material*, or, in other words, certain simple elementary forms into which musical sounds are arranged, as preliminary to the more complex designs that are afterwards built up from them.

This plan is quite consistent with the analogy of other cases. In language our raw material is, in writing, letters; in speaking, vowel and consonant sounds;—these have to be arranged in the first instance into words, which have then to be combined into grammatical sentences. Or take an

analogy used before, that of building structures. Nature provides rough stone in the quarry, or clay in the field, or woody fibre in the forest, or ironstone in the mine; but these, before they can be used by the architect or engineer, must be fashioned into primary or elementary forms—the stone into squared blocks, the clay into bricks, the timber into baulks or planks, and the iron into bars.

And so, in music, we have analogous primary or elementary arrangements of the material, which the composer, like the grammarian or the architect, uses for his structural operations. And, since we are investigating first principles, it is clearly philosophical and logical to devote careful attention to these before we attempt to go farther.

The simplest application of musical sounds is to form *melody*, which consists, as has been said, of a series of single musical sounds taken in succession. Everybody accustomed to music knows what is meant by a *tune* or *air*, such as is sung by a single voice, or played by an instrument one note at a time: and this is what is called a melody.

There are several features which must be combined, to form what, in modern music, is considered a proper melody; but the most essential and fundamental one is, that the notes must not be taken at random among all possible sounds: they must be selected from a certain *definite series*.

It has been already stated that the number of sounds producible, all differing in pitch, is theoretically infinite, and is practically very large; so that in a single octave a sensitive ear may distinguish 50 to 100 different sounds. But if we were to take a number of these sounds at random, or to slide by a continuous transition from one sound to another, we should not make what we call music. In order to do this we must use only a certain small number

For example, in ascending from any note to its octave, we proceed by a succession of definite steps or degrees. These steps may vary in magnitude and position, but for our ordinary modern music we use *seven* steps, of unequal height, having sometimes smaller steps interposed between them.

Such a series or succession of sounds is called a *scale,* from its analogy with the steps of a staircase (Latin, *scala*). The French use the same term as for a ladder, *échelle;* and the Germans call it *Tonleiter,* or ladder of musical sounds.

We need not here trouble ourselves as to how the steps should be arranged; that will be the subject of the following chapters. The point to be made out here is, that in order to make what is called music there must be *some limitations* in the number of notes that are used, and that a *definite series* of some kind must be adopted, from which the notes of melody must be chosen.

Now it is evident two theoretical questions arise here—

1. Why is there this limitation in the number of the sounds that may be used? And

2. On what principle is the selection made to form an allowable scale?

First, then, why need there be any particular selection or limitation of the sounds to be used? Why cannot melody be made by using any we please out of the infinite number of sounds possible? Why is it necessary to proceed by steps, and forbidden to progress by continuous transitions? The question is a curious one. It appears to be a fact that all nations, in all times, who have made music have adopted such a selection, although they have not always selected the same series of sounds.

Helmholtz is the only person who has attempted to give an answer to this question. His explanation is somewhat

metaphysical and difficult, but it appears to be essentially as follows :—

He believes that the reason is a psychological one, and is of the same nature as the feeling which has led to rhythmical division in poetry and music.

The essence of melody is motion; and this motion, in order to produce its proper effect, must be effected in such a manner that the hearer can easily, clearly, and certainly appreciate the character of that motion by *immediate perception.* But this is only possible when the steps of this motion—their rapidity and amount—are also exactly *measurable* by immediate perception. Therefore the distance between the various successive notes must be definite and positive, and the alterations in pitch must proceed by regular and easily appreciable degrees.

It may be objected that continuous curved lines in design, addressed to the eye, not only produce a pleasing effect, but are usually considered more beautiful than angular stepped transitions of form; and by this analogy the continuous progression of sound might be supposed to be more pleasing to the ear than abrupt change.

But Helmholtz has an ingenious answer to this. He says that the eye which contemplates curves can take in and compare all parts at once; or can at least return backwards and forwards, so as to get a comprehensive simultaneous idea of the whole. But the individual parts of a melody reach the ear in *succession;* we cannot observe backwards and forwards at pleasure. Hence, for a clear and sure measurement of the change of pitch, no means is left but progression by determinate degrees. When the wind howls, and its pitch rises or falls, in continuous gradation, we have nothing to define the variations of pitch, nothing by which we can compare the later with the earlier sounds, and comprehend the extent of the change; the whole phenomenon produces a confused impression, which, whatever else may be its character, is certainly not music. The musical scale (or definite series of

notes) is, as it were, a divided rod by which we measure progression in pitch, just as rhythm measures progression in time.[1]

Helmholtz shows, by a quotation from Aristotle, that the ancients had this idea of the analogy between the scale of tones and the scale of rhythms; and further remarks, that we consequently find the most complete agreement among all nations that use music at all, from the earliest to the latest times, as to the separation of certain determinate degrees of pitch, these degrees forming the *scale* in which the melody moves.

Whether this explanation is fully satisfactory or not, at any rate it is novel and ingenious, and probably the best that can be given.

The second question, namely, On what principles is the selection of sounds made to form an allowable scale? is a much wider one, and will require more study to answer.

[1] A continuous slide between two notes, on instruments that will effect it, as the voice or violin, is admitted in music, as an ornament, under the name "portamento;" but the two ends should be definite, and it should be sparingly used. It is often grossly abused by ignorant or tasteless singers.

CHAPTER VI.

MUSICAL INTERVALS.

BEFORE we can make any progress in investigating the formation of scales, we must consider the proper mode of *defining the steps* or degrees of which they are composed.

The step or distance from one musical sound to another of different pitch, is called, in musical language, an *interval*, and it will be well here to consider the subject of intervals generally, and to show how their *magnitudes* are determined and expressed.

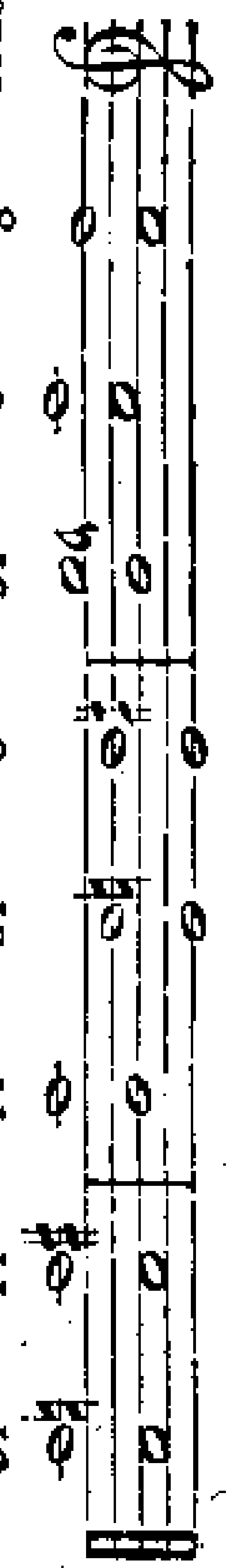
In the first place, it may be remarked that, in practical modern music, certain *defined* intervals have received certain names, and are referred to a practical scale of magnitude determined empirically. The nomenclature of these intervals is usually taught as one of the first steps to a knowledge of harmony or practical composition, and it will be sufficient therefore to refer to a diagram, which contains all the intervals in ordinary practical use.

The determination of their several values will be explained in Chap. XII.

TABLE OF MUSICAL INTERVALS IN ORDINARY USE.

	UNISON.		SECOND.				THIRD.			FOURTH.			FIFTH.		
	Perfect.	Augmented. (*Chromatic Semitone.*)	Minor. (*Diatonic Semitone.*)	Major. (*Minor Tone.*)	Major. * (*Major Tone.*)	Augmented.	Diminished.	Minor.	Major.	Diminished.	Perfect.	Augmented. (*Tritone.*)	Diminished.	Perfect.	Augmented.
Semitones.	0	1	1	2	2	3	2	3	4	4	5	6	6	7	8
Ratio of Vibrations.	$\frac{1}{1}$	$\frac{25}{24}$	$\frac{16}{15}$	$\frac{10}{9}$	$\frac{9}{8}$	$\frac{75}{64}$	$\frac{256}{225}$	$\frac{6}{5}$	$\frac{5}{4}$	$\frac{32}{25}$	$\frac{4}{3}$	$\frac{45}{32}$	$\frac{64}{45}$	$\frac{3}{2}$	$\frac{25}{16}$
Logarithm of Ratio.	0	18	28	46	51	69	56	79	97	107	125	148	153	176	194

TABLE OF MUSICAL INTERVALS IN ORDINARY USE (*continued*).



Interval		Semitones.	Ratio of Vibrations.	Logarithm of Ratio.
SIXTH.	Minor.	8	$\frac{8}{5}$	204
	Major.	9	$\frac{5}{3}$	222
	Augmented.	10	$\frac{225}{128}$	245
SEVENTH.	Diminished.	9	$\frac{128}{75}$	232
	Minor.	10	$\frac{16}{9}$	250
	Major.	11	$\frac{15}{8}$	273
OCTAVE.	Diminished.	11	$\frac{48}{25}$	283
	Perfect.	12	$\frac{2}{1}$	301
COMMA. (Equal to a Major Tone *minus* a Minor Tone.)			$\frac{81}{80}$	5
PYTHAGOREAN COMMA. (Equal to 12 Perfect Fifths, *minus* 7 Octaves.)			$\frac{3^{12}}{2^{19}}$	6
ENHARMONIC DIESIS, as C♯ to D♭. (Equal to a Diatonic Semitone, *minus* a Chromatic Semitone.)			$\frac{128}{125}$	10
MEAN SEMITONE.			$\frac{\sqrt[12]{2}}{1}$	25

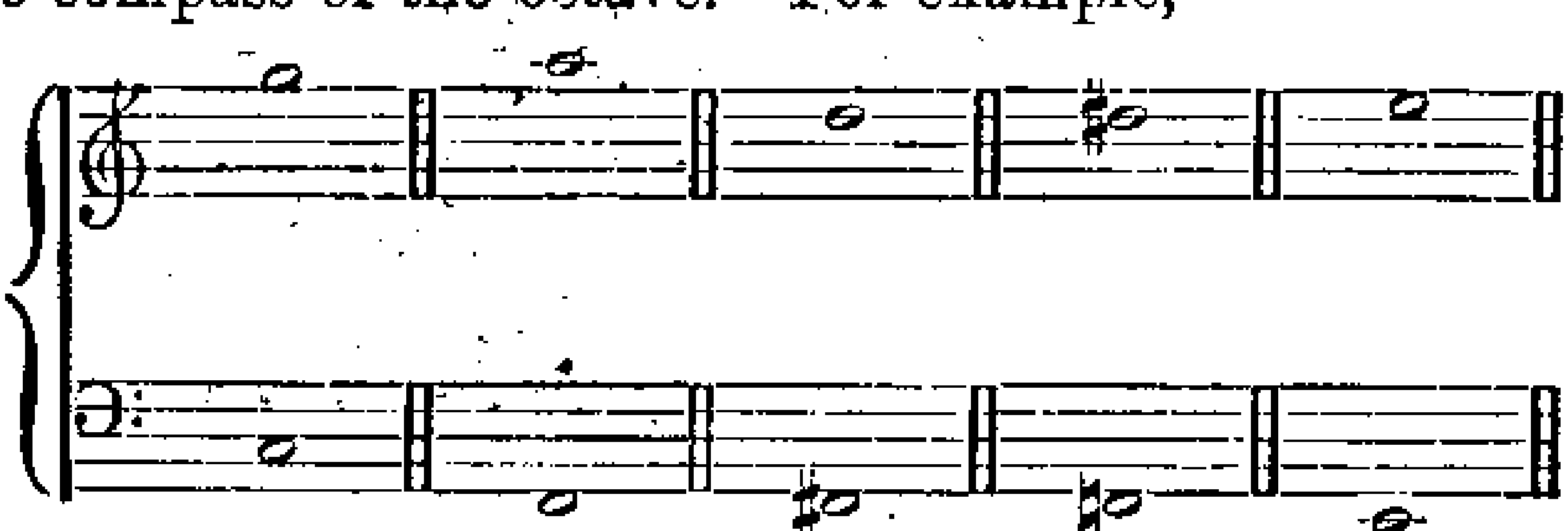
The intervals in the foregoing table are limited to the extent of an octave. The nomenclature of those exceeding an octave may easily be deduced. For example,

is called a minor ninth; it consists of a minor second *plus* an octave; it contains $1 + 12 = 13$ semitones; its ratio is $\frac{16}{15} \times 2 = \frac{32}{15}$; and its logarithmic equivalent is $28 + 301 = 329$.

Similarly

is a major seventeenth, consisting of a major third plus two octaves; its ratio is $\frac{5}{4} \times 4 = \frac{5}{1}$, and its logarithm $= 97 + 602 = 699$.

A few of these intervals greater than the octave are, in the practical rules for harmony, treated distinctly and individually; the ninths, for example, major and minor, are of considerable importance, and are distinguished broadly from the major and minor seconds. But as a general rule, when the two notes become very wide apart, the interval is, in practical harmony, assumed to be equivalent to that between two notes of the same name within the compass of the octave. For example,



would be considered as a,

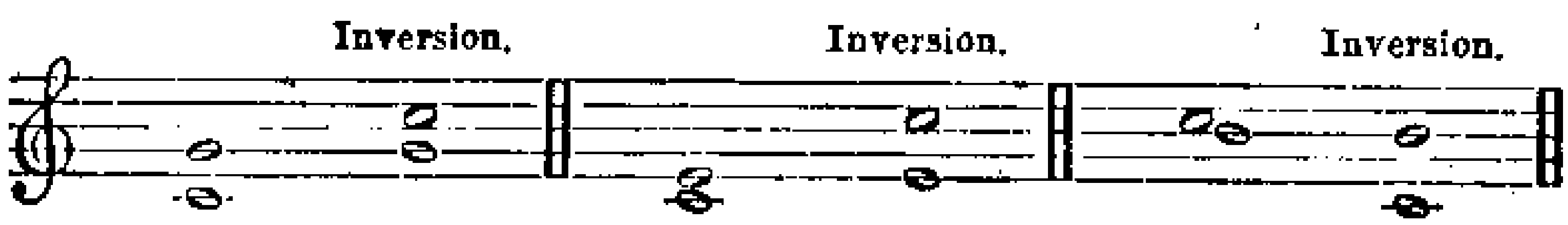
5th. Major 3d. Minor 6th. Augmented 6th. Octave.

And so on.

It must not, however, be inferred from this that intervals widened out by the interposition of octaves remain

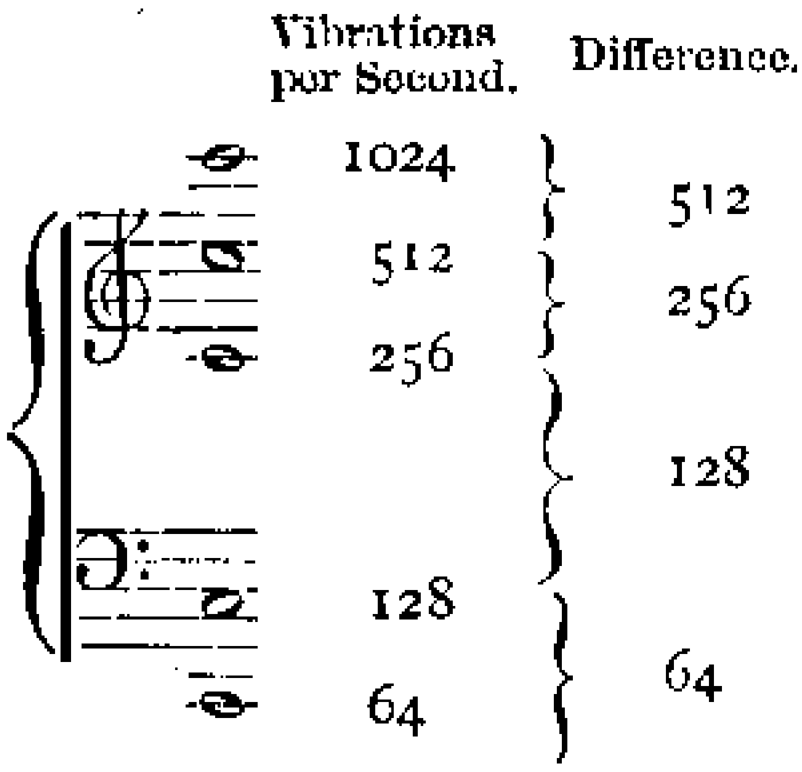
the same in an acoustical point of view. The effect on the ear of a major third, for example, when the two notes are sounded together in harmony, will be materially altered if the interval be increased to a major tenth, and still more if increased to a major seventeenth. This will be explained hereafter under the head of Harmony.

If the relative positions of the two notes of an interval be changed, by raising the lower note or depressing the upper one an octave, the interval is said to be *inverted.* Thus in the following examples a fifth when inverted becomes a fourth; a major third inverted becomes a minor sixth; a minor second becomes a major seventh; and so on.



The unit of magnitude usually referred to in practice as a measuring scale for intervals, is the *semitone* as it is known on the pianoforte. But this, as will be seen hereafter, is an empirical and not a scientific datum. And besides, as the number of possible sounds is theoretically unlimited, so the number of possible intervals is theoretically unlimited also. Hence, for theoretical purposes, a more comprehensive and philosophical system of definition and measurement is necessary.

We have seen that the *pitch* or degree of acuteness of musical sounds depends on the rapidity of the vibrations that cause them. Hence it is possible to imagine a scale of acuteness analogous to the scale of a thermometer, and to fix the position of any musical sound in the scale, according to its corresponding vibration-number, as in the following example:—



This being so, if we want to define the *interval* between any two sounds, the simplest way would appear to be to take the difference between the vibration-numbers of the upper and lower sounds, just in fact as we should do in taking differences of temperature on the thermometer. But this will not do, for a reason specially musical, which prevents the application of this analogy of ordinary scales. It is found by experience that the impression produced on the ear in different cases does not accord with the differences between the vibration-numbers.

An example will make this clear. The notes in the preceding diagram are all repetitions of the same note in different octaves; and it is a matter of observation that the same impression is produced on the mind by the interval of the octave wherever it may lie; *i.e.*, the two lower notes give an impression of the same distance apart as the two upper ones, or as any two contiguous ones in the middle. But it will be seen that the difference of the vibration-numbers varies widely in each of the four octaves, and hence it affords no proper measure of the interval in question.

The true measure is the *ratio* of the vibration-numbers of the two sounds, or the higher vibration-number divided by the lower; this will be found in each case the same $= \frac{1024}{512} = \frac{512}{256} = \frac{256}{128} = \frac{128}{64} = 2$ or $2 : 1$, which is established as representing truly the interval of the octave.

Similar cases might be tried to any extent in any part of the scale, and the result would be uniformly that it is

the ratio of the vibrations that is the true exponent of the musical character of the interval. By a similar principle we should find the ratio for—

A fifth	. . . . . .	$= \frac{3}{2}$ or 3 : 2
A fourth	. . . . . .	$= \frac{4}{3}$ or 4 : 3
A major third	. . . . .	$= \frac{5}{4}$ or 5 : 4
A minor third	. . . . .	$= \frac{6}{5}$ or 6 : 5

and so on.

These ratios are inserted in the diagram for all the intervals there given.

This definition by ratios suffices well enough for single intervals, and it is the only one usually given in works on the theory of music. But when the intervals have to be *combined*, and calculations made respecting them, the management of these ratios becomes exceedingly troublesome. For example, if it be desired to add a fifth to a fourth, producing an octave, the ratios must not be *added*, but must be *multiplied* together; thus, $\frac{3}{2} \times \frac{4}{3} = \frac{12}{6} = 2$. Or, if we wish to subtract a major third from a fifth, the ratio representing the latter must be *divided* by that of the former; thus, $\frac{3}{2} \div \frac{5}{4} = \frac{12}{10} = \frac{6}{5}$ which represents a minor third.

To avoid this complexity, and to bring the calculation of intervals into a form more in analogy with that of other philosophical scales, the plan has been adopted of expressing the interval, not by the ratio itself, but by the *logarithm* of the ratio. This plan gives the great advantage that intervals so expressed may be added or subtracted, precisely as linear measures, or degrees on any other scale.

The mode of finding the logarithm for any interval is exceedingly simple. The interval being expressed by its ratio in the form of a fraction, take, from any ordinary table of logarithms, the logarithms corresponding to the two numbers of which the fraction consists; then subtract the lesser number from the greater, and the remainder will be the logarithm required. The published tables usually

give the logarithms to 5, 6, or 7 places, but the first three figures will suffice for all ordinary purposes of musical calculation.[1]

Thus for the interval of the fourth, which corresponds to the fraction $\frac{4}{3}$, we should find by the tables—

Log. 4	= 602
Log. 3	= 477
Log. representing the interval of the fourth . .	= 125

Here, therefore, we get a philosophical mode of great simplicity for expressing the interval between any two musical sounds whatever, no matter whether consonant or dissonant, or even whether they belong to the musical scale at all. If we can only identify the two sounds by the numbers of their vibrations, the logarithm of their ratio will give an accurate representation of the interval in a way far exceeding any other method in intelligibility and practical clearness.

The logarithmic values for the different intervals in ordinary use are inserted on the diagram.

As an example of the accuracy of this mode, it may be shown how exactly the definitions thus obtained correspond with the ordinary practical notions of the nature and magnitude of intervals.

	Logarithm.
A fifth	176
Added to a fourth . . .	125
Make an octave	301
A major sixth	222
Added to a minor third . . .	79
Make an octave	301

[1] Also for this purpose the customary index and the decimal point may be omitted, and the logarithms considered as whole numbers. Thus the logarithm of 4 is, properly, in 5 places = 0·60206, but it may be treated as simply = 602.

A small cheap table of logarithms is published by Messrs. Spon, Charing Cross.

	Logarithm.
A minor sixth	204
Added to a major third	97
Make an octave	301
A major third	97
Added to a minor third	79
Make a fifth	176
A fourth	125
Added to a major third	97
Make a major sixth	222

It is one great advantage of the logarithmic mode of expressing intervals, that by laying the logarithms down on paper, or, as it is termed, "plotting" them, to any convenient size, a representation may be given to the *eye* of the relative magnitudes of the intervals, analogous to the impression which they make on the ear.

Further explanations of this, with examples, will be found in Chaps. XI. and XII.

To express the value of an *inverted* interval, first invert the fraction, and then multiply it by 2. Thus the inversion of a fifth $\frac{3}{2}$ is $= \frac{2}{3} \times 2 = \frac{4}{3}$, *i.e.*, a fourth.

In logarithms, simply deduct the value of the interval from 301, the logarithm of the octave.

CHAPTER VII.

HISTORY OF THE MUSICAL SCALE.[1]

We may now proceed to the main question, *On what principles is the selection of sounds made, to form an allowable musical scale?*

We are met, at the outset, with the fact, abundantly proved, that the selection has varied considerably among different nations and at different times; and hence it is necessary to notice briefly some cases of the kind, and particularly to ascertain something about the origin of the form of scale we at present use.

These historical considerations are by no means irrelevant to the theory of music, for they often throw light on obscure points of principle. We are too apt in music, as in many other things, to confine our thoughts within

[1] In regard to the historical matter contained in this and subsequent chapters, particularly as to Greek music, the following authorities have been made use of in addition to the work of Helmholtz:—

An Explanation of the Modes or Tones in the Ancient Grecian Music. By Sir Francis Haskins Eyles Styles, Bart., F.R.S. Phil. Trans., 1760.

Article by Professor Fortlage on "Griechische Musik" in Ersch and Grüber's Allgemeine Encyclopædie der Wissenschaften und Künste. Leipzig, 1862.

Harmonik und Melopöie der Griechen. By R. Westphal. Leipzig, 1863.

Histoire Générale de la Musique. Par E. T. Fétis. (Vol. iii. Music of Asia Minor and Greece. Paris, 1872.)

The History of Music. By Wm. Chappell, F.S.A. London, 1874.

Histoire et Théorie de la Musique de l'Antiquité. Par F. A. Gevaert. Vol. I. Gand., 1875.

Euclid's Treatises, Εισαγωγή Ἁρμονική, and Κατατομή Κανόνος. Published in his Complete Works, with a Latin translation by Gregory. Oxford, 1703.

No attempt is made in these pages to give any complete account of the elaborate Greek systems; only those points are mentioned that have an immediate bearing on the theory of modern music.

the comparatively narrow circle of present habits and practices, neglecting the much more comprehensive views that may be obtained by taking a wider range of observation over what has been done before.

In regard to the scale this is particularly the case; for in reality the history of the scale is essentially the history of music itself in its early existence; and it shows, as no other study can do, the nature of the principles which have been at work in forming the art, and bringing it into its present state.

The earliest forms of music probably arose out of the natural inflections of the voice in speaking. It would be very easy to *sustain* the sound of the voice on one particular note, and to follow this by another sustained note at a higher or lower pitch. This, however rude, would constitute *music.*

We may further easily conceive that several persons might be led to join in a rude chant of this kind. If one acted as leader, others, guided by the natural instinct of their ears, would imitate him, and thus we might get a combined unison song.

It is also not unreasonable to conjecture that by means of the memory for successions of sounds, naturally implanted in the human mind, some of these songs might be repeated often and ultimately learned by heart, and thus we should arrive at a simple definite vocal music.

But the question at once arises, What would be likely to be the relations of pitch between the several notes forming such songs? We shall reserve for the next chapter all *theoretical* considerations about this. Here it will be sufficient to confine attention to the facts of history.

Frequent attempts have been made to give written representations of the rude music heard among savage or semi-barbarous nations, but these attempts must always

be received with some distrust, not so much from want of confidence in the observers as from the want of accurate means of representing the sounds heard. The usual practice is to try to write down the sounds according to our modern musical notation; but it must be borne in mind that this notation only corresponds with our own peculiar scales, and that it gives no signs for any notes inconsistent therewith. Hence when we see the chants of a savage tribe expressed in our notes, we must not take it for granted that the people actually used the intervals of our scale. We can only assume that the observer wrote down something, as nearly like what he heard, as he could find expression for.

All that can really be made out about the music of savage tribes is, that they use a few sounds, differing in pitch; but there is no sufficient reason to believe that these sounds correspond, as regards their gradations, with any regular system whatever.

To get traces of such systems we must look to nations more civilised; and we then soon find, not only a considerable advance in the extent of the sounds used, but, what is of more importance, a more accurate definition of them. This definition is very much aided when, as often happens, the nations have introduced musical instruments having the capability of giving fixed tones.

In the case of some ancient nations we find treatises on music, in which the relations of the sounds and the modes of using them are described with some minuteness. In other cases, where such accurate data do not exist, the nature of the scales can often be inferred by indirect means, among which the representations of musical instruments are found most valuable.

Beginning with the yellow or Mongolian race, we find that the Chinese have had a regular system of music, somewhat complex; they appear to have known the *octave*, which is a great step; and, as a matter of theory, they

have divided this interval into twelve equal parts, like our semitones; but they do not use them in a way at all corresponding to ours; they only practically use *five* notes out of the eleven theoretical ones, making a selection of intervals corresponding with the black notes of the piano. There are other instances of the use of this singular scale among more modern nations. The music of Japan is elaborate and complicated, and differs materially from the Chinese; but it presents little or no analogy with our western ideas.

It was reserved for the white race to create the true art of music; but the different nations composing this race have varied considerably in their notions as to the solution of the problem.

The Egyptians had music which, judging by the representations left of their musical performances and musical instruments, had considerable extent and variety. The exact nature of it can only be made out by ingenious inferences, and historians are at issue about their significance. It seems clear, however, that they acknowledged the octave, and that it was largely subdivided.

The music of the Chaldeans, Babylonians, Assyrians, and Phœnicians, may be assumed to have been of a similar character, the octave being also traced among them.

The Hebrews attached much importance to their music, but there appears no means of getting any definite information as to its tonality.

The music of the Arabs seems to involve extraordinary complications, and has furnished endless occupation for musical historians and theorists. Even Helmholtz has been tempted to devote a large space to its peculiarities. The most interesting fact in regard to it is, that the principal intervals of our scale—namely, the octave and fifth—were also the most important intervals with them. But the resemblance ended here; for their octave was divided

into sixteen, or according to some authors into seventeen parts, and these not equal in all cases to each other. So that, generally speaking, their music must have been very different from anything we are accustomed to.

Turning now to the earlier developments of the ethnological family from which we ourselves have sprung—namely, the Aryan—we find in the Sanscrit literature traces of a distinct musical system in India, some three thousand years old, and which is still cultivated there. They also have the octave division, which is subdivided theoretically into twenty-two parts. Like the Chinese, however, they do not use all these notes; their practical scale consists of seven degrees, among which the twenty-two theoretical intervals are unequally divided. The notes in the usable scale admit of many changes, forming distinct *modes,* and the system generally has many analogies with that of the Greeks.

It is worthy of remark, however, that, judging by the frets on their principal stringed instruments, the subdivision of the octave by the fifth and fourth is clearly acknowledged.

Another Aryan branch—the Persian—presents great interest for us, because, so far as the early history of nations can be made out, their music seems to have been the remote ancestor of our own. The Aryans of Persia had originally, like those of India, a liking for minute intervals of sounds, for they divided the octave into twenty-four parts, which would be equivalent to what we should call quarter tones, each interval being half our semitone.

It is through the known migrations of these races westwards, and particularly into Greece, that their connection with our music is genealogically established. Under the name of Pelasgians they settled in Asia Minor and in Greece some two thousand years before the Christian era, and their descendants, called Lydians and Phrygians,

afterwards mixed with colonists from other parts—Dorians, Æolians, Ionians, &c.—who exercised considerable influence on their manners and customs.

The early history of Greek music is enveloped in great obscurity; it is only when we come to the time of Pythagoras, *i.e.*, in the sixth century before the Christian era, that any positive information about it can be obtained. So far, however, as can be made out by inference and conjecture, the progress of events may have been somewhat as follows:

The earliest indications of a regular system are found in the little that is said of the poet-musician, Olympus, who was a Pelasgian by origin, and lived about two hundred years before the siege of Troy, or B.C. 1400. And it is consistent with what has been said of the ancient music of the Persians, that the Greeks attributed to Olympus the introduction of what they called the *enharmonic genus*, in which very small intervals were used.

This, however, was a long way from the diatonic system, and a great change is supposed to have been brought about by the entrance among the Pelasgians of the foreign colonists before-mentioned. The influence of these people, more heroic and energetic, was to do away with the more delicate estimations of sounds, and to bring about arrangements in which the intervals were larger. Hence came into vogue certain musical forms which took the names of the people they were due to, and three of these, namely, the Dorian, Phrygian, and Lydian, are particularly to be mentioned, because, as we shall see in a future chapter, they, or at any rate something akin to them, took at a later date a permanent place in the Greek system, and gave corresponding varieties of character to the music, the influence of which has been perpetuated down to our own day.

It is impossible now to trace the exact nature of the

changes that took place, or to define with accuracy the structure of the music at that early date. There was then no fixed guide for settling or for recording the pitch of the notes, as the tuning was entirely done by ear; and hence there has been no means of handing down to posterity any description of the music, except such as could be made out by tradition. There is reason, however, to believe that about the seventh or eighth century before Christ, the chief element of music had become reduced to a series of *four notes*, which were sounded by the four strings of the lyre, and formed what was called a *tetrachord*.

It is pretty clear that the two extreme strings of this tetrachord were set to an interval of a *fourth*, seeing that this interval remained, through all subsequent improvements, the chief element of the Greek musical scale.

The tuning that was used for the two intermediate strings must be, for the reason above assigned, a matter of uncertainty; probably there were several varieties more or less in use (as, in fact, there were always afterwards), but it would seem that one mode of division of the fourth had some resemblance to what we now know as two tones and a half-tone (see page 95).

At any rate the tetrachord, whatever it was, was improved about 670 B.C. by *Terpander*, who added three more strings above it, forming two tetrachords, with one note in common. This junction-note was called *Μέση*, *Mesē*, the middle note, and was considered the most important of the whole.

Such was the state of music, so imperfect as hardly to deserve the name of a system, when there arose, about a century after Terpander, a great philosopher, Pythagoras, whose genius enabled him not only to effect great improvements in the capabilities of music, but to establish for the art a definite and scientific basis intelligible and available for all time. He was, indeed, the founder of theo-

retical music; for it was he who first traced out the laws which governed the relations of sounds to each other, and by this means brought music within the domain of natural philosophy. He established the principle that intervals could be appreciated intellectually by the aid of *numbers*, instead of, as formerly, by the ear alone. "Sense," he said, "is an uncertain guide; numbers cannot fail."

The way in which Pythagoras effected this was by means of the stretched strings used for the lyre. He had acuteness enough to perceive the fundamental fact (explained in chap. iv.), that the *length* of the string might be made to supply an exact definition of the pitch of the note it sounded. Hence he was enabled to attach to each sound a certain numerical value, and thus to compare it with other sounds, and to establish positive and definite relations between them. The instrument which Pythagoras used in these investigations was called a *canon* (*κâνων*), and appears to have been identical with our monochord.

The importance of this step, connecting for the first time music and mathematics, can hardly be overrated; and as the method Pythagoras introduced has become verified and established in use by all subsequent experience and investigation, he is fairly entitled to be called the Father of Musical Science.

The introduction of the Pythagorean musical philosophy was followed by a large practical extension of the scale, in which Pythagoras himself no doubt took some share. He had been in Egypt, and it is probable that he had obtained there information which had considerably enlarged his views. In the simplifying changes that had taken place in Greece, the octave seems to have lost much of its early significance, and one of the most important improvements of Pythagoras was to restore the importance of this useful interval.

In studying the divisions of his string, he perceived

that the simplest of these divisions, namely, into two equal parts, gave a note which his ear told him had obvious musical relations with the fundamental one, and this settled for all time the predominance of the octave over all other musical intervals.

Having thus established the octave, Pythagoras set himself to apply the same philosophical principles to determining its subdivisions. Referring again to his measuring instrument, the string, he proceeded categorically to get, by its means, other divisions of smaller value.

To produce the octave he had divided the string into two parts; he now tried dividing it into three; and he found that two-thirds the length of the original string would give an interval that would conveniently subdivide the octave. This interval we now call the *fifth.*

Again following the same principle, he next divided his string into *four* equal parts, and he found that three-fourths the length of the string gave another subordinate division at an interval which we now call the *fourth.*

He could not fail to perceive a remarkable symmetry in these two arrangements; for the fifth, reckoned upwards from the lower note of the octave, gave the same note as the fourth reckoned downwards; and, *vice versa,* the fourth reckoned upwards gave the same note as the fifth downwards. Thus the octave proved to be made up of a fourth and a fifth added together.

These three intervals, as settled by Pythagoras, have been ever since the most important intervals in music, and we shall hereafter see much more of them.

The determination of the fifth and the fourth gave a means of establishing with precision an interval of much smaller dimensions, namely, the *difference* between them. This was called a *tone* (τόνος), and its value may be easily illustrated by our logarithmic numbers, thus—

The interval of a fifth ($\frac{3}{2}$) is expressed by	176
The interval of a fourth ($\frac{4}{3}$) by	125
These added together make an octave ($\frac{2}{1}$)	= 301
The difference between the fourth and fifth gives the *tone* ($\frac{9}{8}$), represented by	51

This new interval formed an appropriate means of completing the subdivision of the octave. But in applying it, Pythagoras seems to have striven to fall in with the ancient prepossessions of the Greeks in favour of the tetrachord, or four-stringed arrangement. Terpander had connected two tetrachords together by a note common to both, so giving the combination an extent of seven notes. But on the introduction of the octave a different arrangement was made. By the intervals of the fourth and fifth, the octave was made to comprise two tetrachords, not joined together as in Terpander's arrangement, but having an interval of a tone between them. While Terpander's combination may be represented thus—

A — D
E — A,

the new arrangement became—

E — A (*tone interval*) B — E,

so completing the octave.

For this reason the second or higher of the tetrachords was called *Diezeutic*, or disjunct.

The subdivision of the tetrachords was made by means of the tone. But this led to an unequal division, a fourth containing two tones, *plus* something over; and this overplus was called a *hemitone* (*ἡμιτόνιον*), as it was nearly, though not exactly, half a tone.

This will be clearly seen by the logarithmic values—

Tone	51
Tone	51
Hemitone	23
Interval of the fourth	125

Or in the more ordinary mode of expression—

Tone.		Tone.		Hemitone.		Fourth.
$\frac{9}{8}$	$\times$	$\frac{9}{8}$	$\times$	$\frac{256}{243}$	$=$	$\frac{4}{3}$

Here, therefore, was an arrangement of four notes, which, while it satisfied the ancient Greek tradition of the tetrachord, was brought within Pythagoras's more accurate notions of musical division. And although the Pythagorean system established the octave as the natural great division for the musical scale, the tetrachord still stood as the popular element, and so it remained for a great length of time.

This division of the tetrachord into two tones and a hemitone was called the *Diatonic System* (γένος διάτονον).[1]

The peculiar arrangement of the two tones and the hemitone in any tetrachord was arbitrary; and it might have three varieties, the hemitone being at the bottom, in the middle, or at the top. These varieties are clearly described by Euclid, and are believed to have corresponded with the traditions of the ancient scales of the Dorians, Phrygians, and Lydians respectively. They were distinguished as follows:—

Dorian Tetrachord.	*Phrygian Tetrachord.*	*Lydian Tetrachord.*
Tone.	Tone.	Hemitone.
Tone	Hemitone.	Tone.
Hemitone.	Tone.	Tone.

The first of these, namely, the Dorian variety, appears to have been considered the most orthodox, and according to this, the octave became divided up in the following manner:—

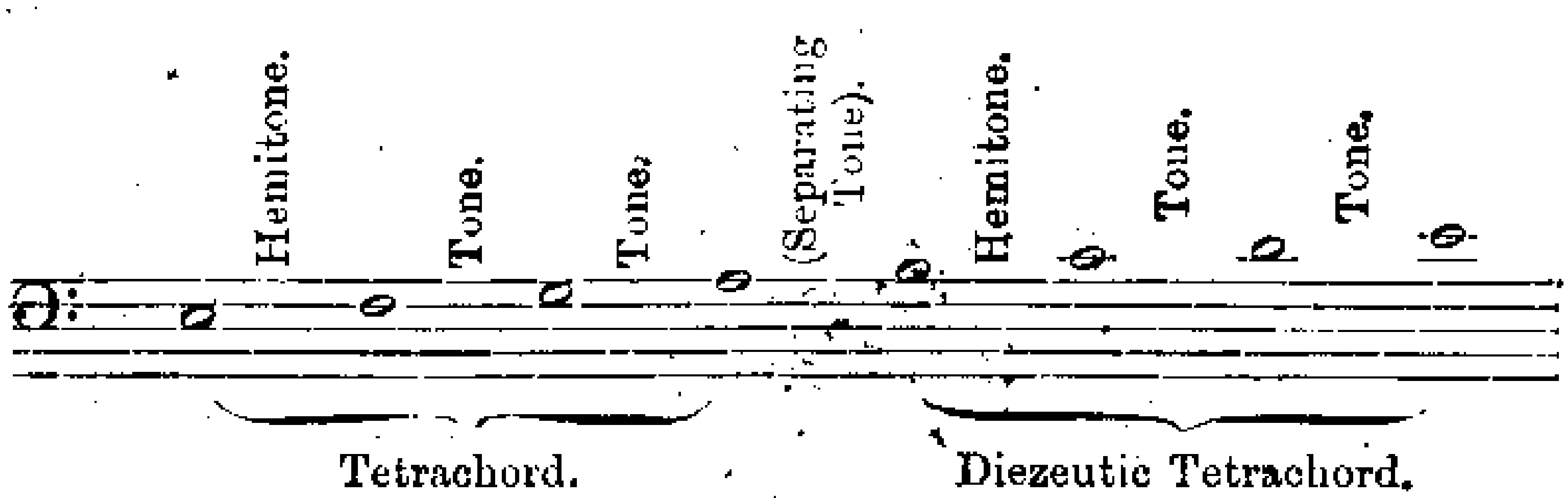
[1] Two other divisions of the tetrachord used in Greece were—

Chromatic Genus.	*Enharmonic Genus.*
A tone and a half.	Two tones.
A hemitone.	A quarter tone (δίεσις).
A hemitone.	A quarter tone.

		Magnitude of Interval.
Diezeutic or disjunct Tetrachord	Tone	51
	Tone	51
	Hemitone	23
Separating tone		51
Tetrachord	Tone	51
	Tone	51
	Hemitone	23
Octave		301

In this way the octave was made to consist of eight notes, comprising seven unequal intervals, arranged on the principle of the *tone,* as a convenient measure; and thus was completed the *diatonic scale,* which has been the foundation of all subsequent music.

The analogy of the above division with our modern scale will be at once evident; indeed, we may express it perfectly well in our modern notation, thus—



The three most important intervals, as settled by Pythagoras, were given names corresponding to the number of notes they comprised.

The *fourth,* comprising four notes, was called *Dia tessarōn,* "through four." The fifth, comprising five notes, was named *Dia pente,* "through five." The octave, which comprised the *whole* of the notes in the system, was named *Dia pasōn,* "through all." This latter term is a standing testimony to the Pythagorean principle, that the octave essentially comprised within itself all sounds so far as their musical relations were concerned, although the full

significance of this great fact did not come into prominence till many centuries afterwards.[1]

The principle of the octave having been once established, it was obviously easy to extend the scale, upwards or downwards, or both, by adding octaves of notes previously existing. This was done, and the scale was at length enlarged to two octaves. Keeping still faithful to the time-honoured tetrachords, one was added above and one below, and then, as one additional note was still wanting to complete the two octaves, this was added separately at the bottom of all, being termed *Proslambanomenos*, or "additional."

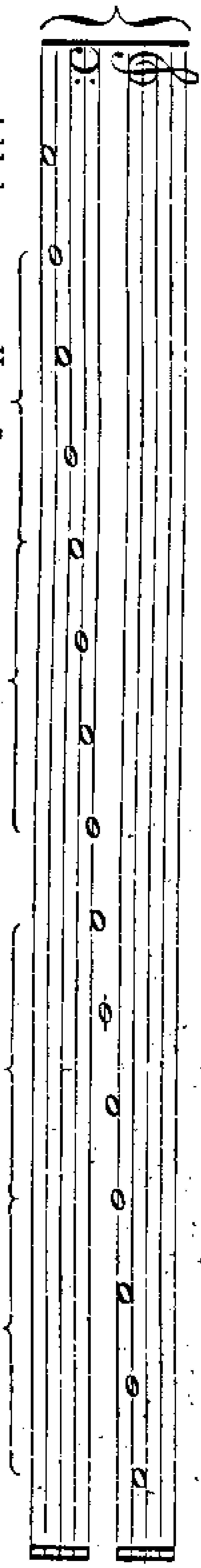
This was the *enlarged system of Pythagoras*, and as it forms a very complete scale, it will be worth while to present it entire. We may assume (which is probably not far from the truth) that the Proslambanomenos may be represented by the low A of a male voice, and then, borrowing our modern notation, we have the scale as on next page.

There is no doubt as to the correctness of this, as the authority exists in an admirable description of it left on record by no less a person than the immortal geometer, Euclid, who lived about B.C. 300, some two hundred and fifty years after Pythagoras's time. This description was called by him *Κατατομή Κανόνος*, "Division of the Monochord," and in it he gives the propor-

[1] Another mode may be, and often is, adopted in showing the Pythagorean construction of the diatonic scale, in which only the intervals of the octave and fifth are used. Starting say from C, and going upwards continually by fifths, the first will give G, the second D, which will have to be lowered an octave; the third will give A, the fourth E, which must be lowered an octave, and the next fifth will give B. If, then, we add an F, a fifth below C, we shall complete the seven notes of the scale, and these will come precisely in the same places as those described in the text.

If we suppose the progression of fifths continued from C upwards twelve times, it will give a note which according to our chromatic notation may be called B♯, and will be, if brought seven octaves lower, very near the original C, being about a fourth of a semitone above it. Pythagoras was aware of this, and the difference is called the *Pythagorean comma*. Its value is $\frac{3^{12}}{2^{19}}$ or in logarithms .0059.

THE GREEK DIATONIC SCALE.



tionate lengths of string corresponding to the various notes of the scale—a mode of determination quite positive and conclusive.

The names attached by the Greeks to the several notes, or strings of the lyre, differed in the two octaves; for although the close musical relation between a note and its octave was admitted and appreciated, yet the Greeks never arrived at the simple plan of naming both by the same symbol.

The middle note, *Mesē*, was considered of special importance, and, indeed, had been so ever since the time of Terpander.

It will be noticed that all the four tetrachords contained in the scale are divided alike, according to the Dorian variety, which, as already stated, was the one of most frequent application.

Although the normal position of the two-octave scale, in actual pitch, is usually taken from the bass to the treble A, as shown in the diagram, it must be understood that it was capable of transposition, and was, in practice, used at many different varieties of pitch, as will be seen in Chap. IX.

Now it is obvious that in this Greek series of notes, proved to be in use about two thousand years ago, we have our diatonic scale. In fact the notes as given here precisely correspond with the series of natural keys of our modern organ or pianoforte. This can easily be accounted for; the *organ* was a Greek instrument, having keys to sound the various notes as with us; and the keys of the Greek organ would naturally correspond with the notes of the Greek scale. The organs afterwards introduced into churches were copied from the Greek ones, and our clavier instruments generally are descendants of the same family. Hence it comes that the chief keys of all these instruments correspond with the Greek series of notes; and we thus see what a respectable pedigree may be claimed for our

familiar domestic pianoforte, so far at least as the white keys are concerned. The black keys are a subsequent introduction, for purposes to be considered hereafter.

In addition to the names given in the diagram, the later Greeks denoted the various sounds by arbitrary characters. The Romans adopted the scale, but abolished all the Greek designations, and named the fifteen notes by their own Latin letters, from A to P inclusive.

Near the end of the fourth century, Ambrose introduced music into the service of the Church, adopting, with the Romans, the simple Greek diatonic scale.

Two centuries later, Gregory amplified and improved the work of his predecessor, and introduced a great simplification in the nomenclature. He saw, more clearly than any one did before him, the great musical principle established by Pythagoras of the analogy between octaves of the same note; and he proposed, in consequence, to denote octave replicates by *the same Latin letter*, merely varying the *character* in which they were expressed. Thus, for the first octave, he used the capital letters A, B, C, D, E, F, G; for the next octave above, the small letters a, b, c, d, e, f, g; for the third octave, the small letters doubled aa, bb, cc, and so on. It is hardly necessary to say of what immense advantage to the study of music this simplification has been.

At the end of the tenth century came Guido d'Arezzo, who is credited with three improvements in regard to the scale. First, he *added a note* one tone below the Pythagorean Proslambanomenos, or Roman A, giving this note the name of the Greek letter *Γ* (gamma); secondly, to facilitate the practice of singing at sight, he abolished the old tetrachord idea, and re-divided the scale into series of six notes or *hexachords*, giving to the various notes of each the well-known names Ut, Re, Mi, Fa, Sol, La (derived

either invented or improved the notation of the scale on lines and spaces, in a manner similar to that we at present use.

As we come down to a date nearer our own time, we get involved in other elements which become very prominent, such as the introduction to a large extent of chromatic notes, the influence of harmonic combinations, and the now indispensable condition of tonality. But the *diatonic scale has remained essentially unchanged:* as the series of notes was when Euclid described it, so it is now; and as it formed the basis of the melodies of the Greeks two thousand years ago, so it forms the basis of the tunes of the present day.

CHAPTER VIII.

THEORETICAL NATURE OF THE DIATONIC SCALE IN ITS ANCIENT FORM.

THE facts brought forward in the last chapter to explain the origin of our present diatonic scale are specially important, inasmuch as they bear materially on the theoretical consideration of the question.

There is a very common, but very erroneous, notion prevalent as to the nature of the series of sounds used in modern music. Many people, and among them some thoughtful musicians, are disposed to believe that the succession of notes in our present diatonic scale is suggested directly by the laws of nature. It comes natural to them to sing the scale, and they imagine that this is the result of some *natural instinct* which prompts them to adopt this exact succession of notes as peculiarly pleasing and satisfactory to the ear.

This, however, is entirely a delusion. The impulse to sing the scale only arises from education and habit; it has been impressed upon us ever since we began to learn music, and everything we have heard or performed in our lives has conduced to keep up the idea. John Stuart Mill forcibly speaks of "the magical influence of custom, which is not only, as the proverb says, a second nature, but is continually mistaken for the first." And so it is here.

Several reasons might be urged against this view. One is that the tonal relations of our scale (on which the assumed natural argument is based) are quite modern.

The scale itself essentially existed for centuries before this tonality was brought into common use. And further, if the series is closely examined, there are found (as will be shown hereafter) imperfections and anomalies in it which forbid the assumption that it can be a natural production.

But a conclusive argument against this view is derived from the fact that it is disproved by history; and on this point it may be pertinent to quote a few remarks by the late M. Fétis, the great musical historian. He says—

> "It is an opinion generally held that the succession of sounds known in the modern music of European nations, and formulated by their major and minor scales, is the result of some fundamental and immutable law; and that diatonic music, *i.e.*, music in which the sounds succeed each other by tones and semitones, is the music of nature.
>
> "According to the doctrine of many theoreticians and historians of the art, the sentiment of the necessity of these diatonic relations of sound ought to have preceded every other conception of tonality, and man would have been incapable of imagining a kind of music inconsistent with these relations.
>
> "I do not hesitate to declare that this opinion is absolutely contrary to what history teaches us by facts of the most unquestionable authority.
>
> "We learn by these facts that diatonic music is *not* the most ancient; on the contrary, we have proof that none of the nations of antiquity adopted it, and that there exist still peoples to whom it is entirely strange. The examples of music of the ancients are sufficient to prove the non-existence of this assumed natural law of diatonic progression. It is not difficult to establish among primitive nations systems of sounds altogether differing from it; and it is possible to trace the progressive transformations by which the modern diatonic scale has been developed, at a comparatively late period, from some of the primoidial systems differing from it almost entirely."

Helmholtz also is strong in support of this opinion. He distinctly asserts that the formation of musical scales does not rest on natural laws, but is at least partly the result of æsthetical principles; in which the varieties of national and individual choice begin to appear.

To prove the *natural* origin of the scale, it would be

necessary to show that some *untaught* person would be led to sing it by his untutored power alone, and this is certainly what no human being ever did or could do. It is exceedingly improbable that the interval of the *tone*, on which the diatonic system is based, can ever have presented itself *naturally* to any human mind. It is very doubtful whether any person uninstructed in the modern system of music, could sing a tone by the prompting of his ear alone. We are by education and long custom in the habit of singing the major tone progression, say from C to D, without difficulty; but it would be scarcely possible to get it perfectly in tune without imagining the harmony of the connecting note G. To prove this let any one try to sing, without an instrument, a series of consecutive whole tones, say C, D, E, F♯, G♯, A♯, B♯; in which he can get no aid from the idea of harmony, and see where he will get to at the end. Indeed, even theoretically, this interval is so indeterminate that it is given two different values, according to the different circumstances in which it is used; and the minor tone would be more difficult to sing correctly than the major one.

The *semitone*, which is also an essential part of our diatonic scale, is still more unlikely to be suggested naturally. It is more indeterminate than the tone, as it has, theoretically, several different values. For example, the semitone from C to C♯ measures 18; from C to D♭, measures 28; the Greek hemitone was 23; and the equal division of the octave into 12 parts (which is the semitone on our pianoforte) gives 25. And with all our education, theoretical and practical, in the present day, there is considerable dissension among musicians as to the exact points where the semitones should lie.

It is very probable that, in those cases where primitive nations have been *thought* to use diatonic successions, this impression must have been more imaginary than real, prompted by the erroneous assumption that the sounds ought to correspond with our scale.

And again, in the case of the Greek tetrachord that existed before Pythagoras, there appears no sufficient proof that the succession of sounds was of a truly diatonic nature. It was most probably Pythagoras who first moulded them accurately into that form.

But, although one must admit that the diatonic scale is not, in its entirety, the result of any natural necessity, we must not fall into the other extreme of supposing that the succession of sounds is entirely empirical and arbitrary. It contains some points that are in accordance with natural laws; and we may briefly examine the diatonic scale, as formed by the Greeks, to see how far physical principles have been concerned in its formation, and how much is due to æsthetical choice.

And here we must be careful to avoid an error that our modern associations might easily lead us to fall into, *i.e.*, deducing all the notes of the scale from harmonic relations. Such a process is applicable enough in the present state of knowledge, as will be shown hereafter. But, as has been justly remarked, scales existed long before there was any such knowledge of harmony as we at present possess; and it is clear that in ancient times, when nothing but simple melody was practised, the scale could not have been constructed so as to suit the conditions of a system, the very idea of which did not arise till a thousand years later.

The same thing may occur in regard to our modern idea of *tonality*. The diatonic scale seems to fit in so well with what we think right in our tonal requirements, cadences, modulations, and so on, that many good musicians have been led to imagine that its natural fitness for such purposes has led to its adoption. But here, again, it must be remembered that our prominent idea of tonality is quite modern. The Greeks had no idea of a key or key-note at all analogous to ours, and hence the diatonic scale could not have been fashioned by them to suit the inventions of

a far-distant future. It is clear the scale must be judged of simply by its own inherent form without any adventitious aids.

Considering the very simple state of music at the time the scale was formed, where are we to look for the influences that could have prompted the ear to fix on certain points and divisions of a scale for melodic sounds?

Clearly there was but one source available, namely, *the nature of the sounds themselves.*

Is there, then, anything in the nature of musical sounds which should lead to the definition of points in a musical scale? Helmholtz has given an elaborate answer to the question, which may be simplified as follows:—

The most important feature of the scale is the prominence in it of the *interval of the octave:* it consists of a number of *similar cycles,* each an octave in compass, and every note has its replicates in octaves above and below. Helmholtz believes that the use of the octave was suggested by the *octave harmonics being heard in compound sounds.* He says when any melody was executed on an instrument of a good quality of tone, such as the human voice, the hearer must have heard not only the fundamental notes, but also the harmonic octaves above them, these being the strongest and most prominent of the various harmonics forming the compound tone. Hence voices would be led to *sing in octaves* to each other, and it would be recognised that the upper sounds were only imitations of what the lower ones would produce when heard alone. This, he thinks, would lead to the establishment of the *octave* as the most positive and important interval of melody.

This explanation is reasonable, and the fact of a natural prompting to sing in octaves is corroborated by common experience. If a melody is sung by a male voice, or played on a bass or baritone instrument, a female or a boy with a tolerable musical ear, even if untaught, will have no hesitation in imitating the melody an octave higher; in

fact, so great is the resemblance between the two that many people think they are alike, not appreciating the octave interval between the two series of sounds.

This division into octaves is found to have prevailed universally in all countries and ages where music has been reduced to any kind of rule.

We next, however, come to a more difficult problem, namely, the *subdivision* of the octave; and in this respect the first feature that strikes us, in regard to the diatonic scale, is the *irregularity* of the division. It is certainly a question that requires consideration, why the most natural mode of equal and uniform divisions was departed from in this case?

The answer, no doubt, is, that uniform divisions would not have been easily appreciable by the ear. It would be very difficult for any unaided voice to divide an octave into a number of equal parts. The ear would have no guide at what point to hit the division. Hence it is much preferable to search for some *dividing point* in regard to which some ear-guide can be found; and Helmholtz decides that there is such a point, namely, at the interval of the *fifth*. He points out that in compound sounds the harmonic most prominent after the octave is the twelfth; which forms, with the octave, an interval of a fifth, and is therefore capable of suggesting the interval of the fifth to the ear. He remarks, in corroboration—"This is the reason why unpractised singers, when they wish to join in the chorus to a song that does not suit the compass of their voice, often take a *fifth* to it. This is a very evident proof that the uncultivated ear regards repetition in the fifth as natural." (*See Appendix, Note F.*)

When, therefore, Pythagoras found that this interval of the fifth, dictated by nature, was given by the next simple division of the string to that of the octave—namely, by dividing it into three parts—he could not fail to see the appropriateness of confirming the fifth as the second stand-

ard interval, and it served as a very convenient point for commencing the subdivision of the octave.

The division of musical sounds, first into cycles of octaves, and then with a lesser subdivision by fifths, appears to have been not peculiar to the Greeks, but to have been adopted by almost all nations who had any pretension to systems of music. And this corroborates the idea of these guiding points being dictated by nature.

The next step in the subdivision of the octave is the determination of the *fourth*. This stands in a somewhat different category, as the natural harmonics give no suggestion of a fourth above the fundamental. The origin of this point in the division is therefore more artificial, but still it may be easily accounted for on simple principles.

When the interval of the fifth is once fixed in the mind, there is no difficulty in applying it *downwards* as well as upwards; and if we suppose a fifth measured downwards from the top note of the octave, we get a point which is a *fourth* distant from the bottom note. In fact, the fifth and the fourth are complementary to each other, and the fourth can be easily *inferred* when the fifth is determined.

Pythagoras found that this new interval was given by three-fourths the length of the string; and although the point was not dictated by his ear, like the fifth, he had no difficulty in fixing the fourth as a second convenient subdivision of the octave scale, so dividing it into two symmetrical tetrachords, as already explained. There is a tradition that the most ancient of all the Greek lyres had four strings tuned according to the four notes obtained in this way, *i.e.*, *c—f g—c*. And if so, Pythagoras was anticipated in his main divisions of the scale.

It appears to have been a result of the investigations of Pythagoras that the Greeks, although they may not have used combinations of notes analogous to our harmony,

principal consonant intervals; for Euclid alludes to the consonant blending of a higher with a lower tone in the three cases of the octave, the fifth, and the fourth, as distinguished from all other intervals.

It remains to consider the minor subdivisions. The two gaps of the fourth were too large; in order to make melody, more notes were wanting, and the gaps had to be filled up in some way.

But here no natural guide was found to direct the ear what intermediate notes to choose, and all farther was left to be settled by purely arbitrary means. For this reason many variations might be used in the subordinate divisions.

We have already seen how Pythagoras filled them in, namely, by the application of his artificial interval of the tone; and, as a matter of theory, there is nothing more to be said on the matter, so far as his scale is concerned.

At a subsequent date, a slight alteration was made in the values of the small intermediate intervals, as will be hereafter explained.

CHAPTER IX.

THE ANCIENT MODES.

THE preceding chapters exhibit the origin and nature of our diatonic scale, so far as the succession of its intervals is concerned; but this is not sufficient, for we have yet to notice a peculiar feature which is essential to its modern application. We do not use the series of sounds indiscriminately, but treat them in a certain form of combination. We select one of the seven notes of which the diatonic scale is composed (for the entire series, whatever its extent, may be assumed to consist only of octave replicates of seven sounds), and we invest this note with a special significance, making all the other six subservient to it, under mutual relations, which are of much importance in the structure of modern music. This selected note is called the *key-note* or *tonic*, and the system of relations that hangs upon it is called *tonality*.

In investigating this feature of music, our first step must be to search for any element in the Greek system which had an analogy to it, or which may be considered to have been instrumental to its introduction. And we find such an element in what are called the Greek *modes*. The nature of these has given rise to much discussion, and the subject has been involved in much misunderstanding, partly on account of the obscurity of the explanations of the old writers on the point, but chiefly from the fact of many changes having taken place, from time to time, which involved the nomenclature in great confusion. The first clear perception in modern times of the

true nature of the Greek modes, appears to have been arrived at by a countryman of our own, Sir F. H. E. Styles, who, in 1760, published an ingenious Essay on the subject in the Philosophical Transactions. His ideas received a passing notice in Burney's "History of Music," 1789, but they were fully confirmed at a later period by the exhaustive investigations of learned German critics, and have in consequence been generally adopted in the most authoritative works. The secret of the difficulty has lain (as will be explained farther on) in confounding together, under the same name of "modes," two essentially different systems and varieties of practice that prevailed at different periods.

In the best times of Greece, song was usually accompanied by an eight-stringed lyre, which embraced the compass of an octave, *i.e.*, the highest and lowest strings sounded the same note an octave apart. Then came the question, how the intermediate six notes should be arranged? For, adhering to the diatonic progression of intervals, a little consideration will show that the notes might, by putting the hemitones in different positions, be arranged in seven different ways.

Thus, representing the interval of a tone by T, and that of a hemitone by H, we might have the seven intervals between the extreme notes arranged in either of the following ways:—

1.	H	T	T	H	T	T	T
2.	T	T	H	T	T	T	H
3.	T	H	T	T	T	H	T
4.	H	T	T	T	H	T	T
5.	T	T	T	H	T	T	H
6.	T	T	H	T	T	H	T
7.	T	H	T	T	H	T	T

We are familiar enough in the present day with these varieties of arrangement of notes, in diatonic succession, within the octave, which are called *modes.* Everybody

who has had to do with ancient ecclesiastical music must be acquainted with the several varieties of "church modes," which correspond in their nature with those now under consideration. And not only so, but we have, in modern music, two "modes" of the same kind, the *major mode* and the *minor mode;* the distinction between which consists in a different arrangement of tones and semitones in the octave scale. These latter may be at once identified with two of the varieties in the above table, our major mode being No. 2, and our minor mode (in its natural or descending form) being No. 7. Hence we are justified, according to the nomenclature which has been in use ever since the days of Ambrose and Gregory, in speaking of the seven different arrangements shown in the table, as so many different *modes*, according to any of which the diatonic octave lyre might be tuned.

There is abundant evidence that the Greeks adopted the seven varieties shown in the table. The general arrangement of the seven notes in any octave was called Ἁρμονία, and the different varieties of it were called Εἴδη or σχήματα τῆς ἁρμονίας. Sir F. Styles, in first drawing attention to them, called them different "species of diapason." The earlier Germans translated this expression into *Octavengattungen;* but Westphal, seeing their identity with the modern varieties, at once rightly applied to them the word *Tonarten*, which is used for the modern major and minor modes. This explanation as to the nomenclature is important, because the analogy of these Greek arrangements with the Church and modern "modes," has been in a great measure overlooked, owing to the fact, that it was not customary for the older writers to designate them by this term. We shall here call them indiscriminately either "modes" or "octave-forms."

The general system of these modes was called Σύστημα ἐμμετάβολον, or *variable* system, and each variety was given a separate name, as follows:—

No. 1	was termed	*Mixo-Lydian.*	
„ 2	„	*Lydian.*	
„ 3	„	*Phrygian.*	
„ 4	„	*Dorian.*	
„ 5	„	*Hypo-Lydian.*	
„ 6	„	*Hypo-Phrygian.*	
„ 7	„	*Hypo-Dorian.*	

It was customary for writers to illustrate the nature of the variations in the modes by a reference to the complete diatonic scale; for by putting the extreme notes of the octave in suitable places, it is possible to embrace portions of the scale between them which shall represent every variety of octave-form.

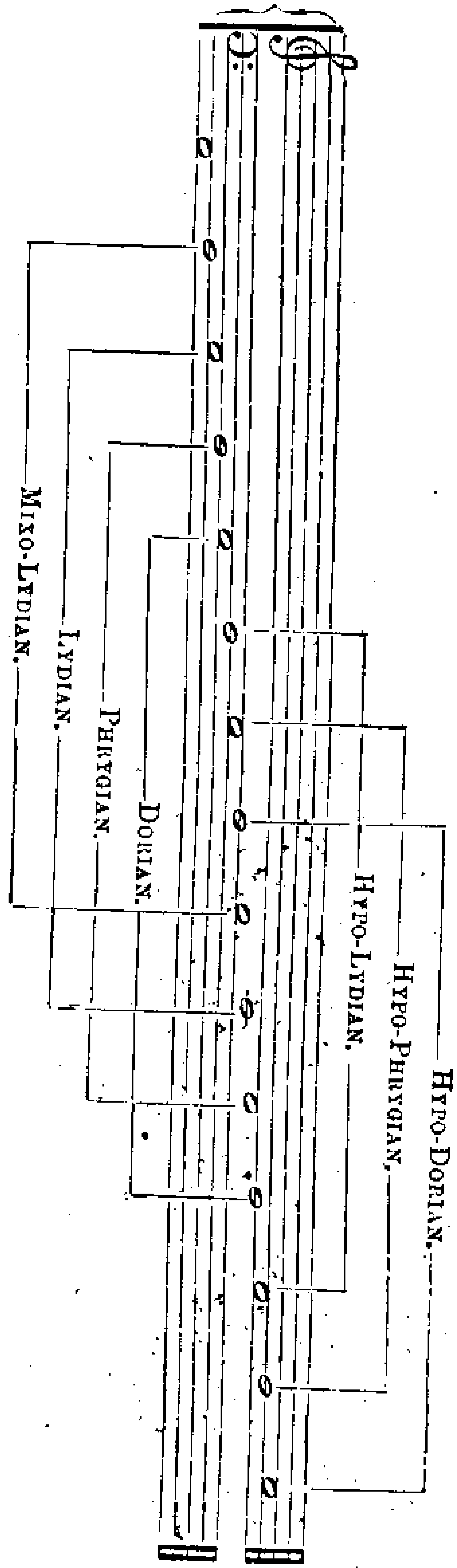
The diagram on page 114 shows how this is done by Euclid, and gives the name attached by him to each mode. There was, however, some variation in the names. The Hypo-Lydian was also called *Syntono-Lydian;* the Hypo-Phrygian was also called *Ionian,* or *Iastian;* and the Hypo-Dorian had also the names of *Æolian,* or *Locrian.*

The Dorian was esteemed the most honourable, but the Hypo-Dorian was the most common (κοινὸς, Euclid calls it); it acquired an importance analogous to that which the major scale has acquired in modern music; and ultimately it became the only one used.

It must not, however, be inferred from this diagram that the several modes were necessarily taken at the pitches there given; they might be taken at any pitch. Sir F. Styles finds reason to believe that at one period it was customary to take the whole of them between the notes *Hypate-Mesōn* and *Nete Diezeugmenōn,* the intermediate sounds being altered accordingly. Whether this was so or not, it is worth while to reproduce the example he gives, as it offers an instructive illustration of the variable characters of the different octave-forms.

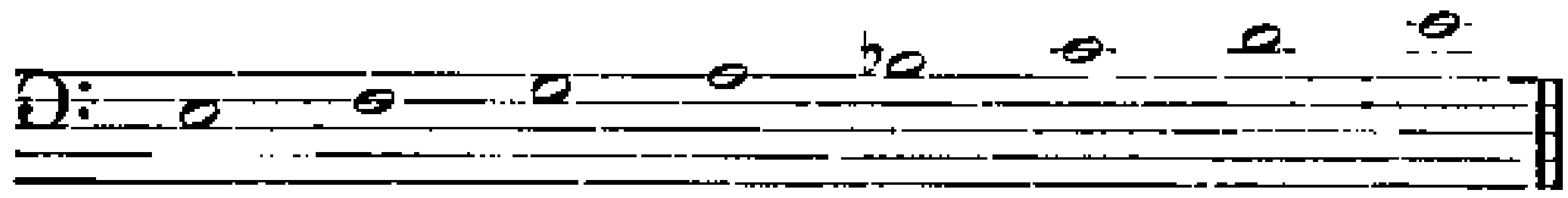
DIAGRAM

ILLUSTRATING THE NATURE OF THE SUCCESSION OF INTERVALS IN THE VARIOUS GREEK MODES OR OCTAVE-FORMS.

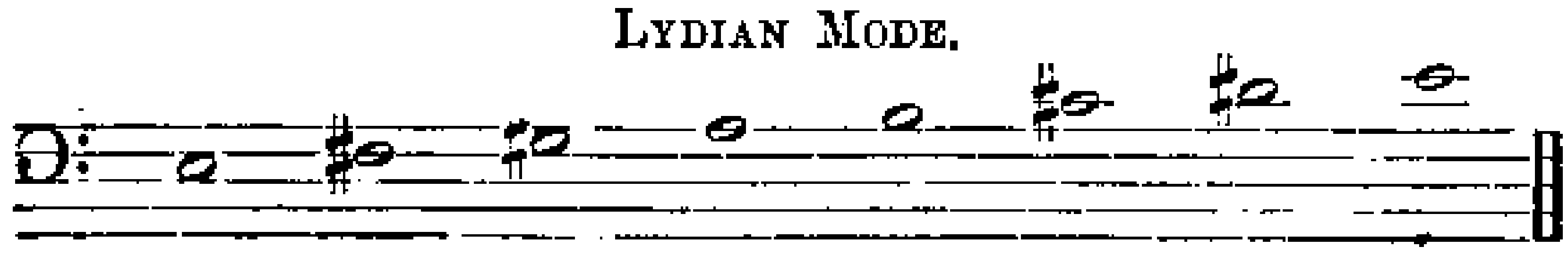


THE SEVEN GREEK MODES, OR OCTAVE-FORMS, APPLIED TO THE SAME PITCH.

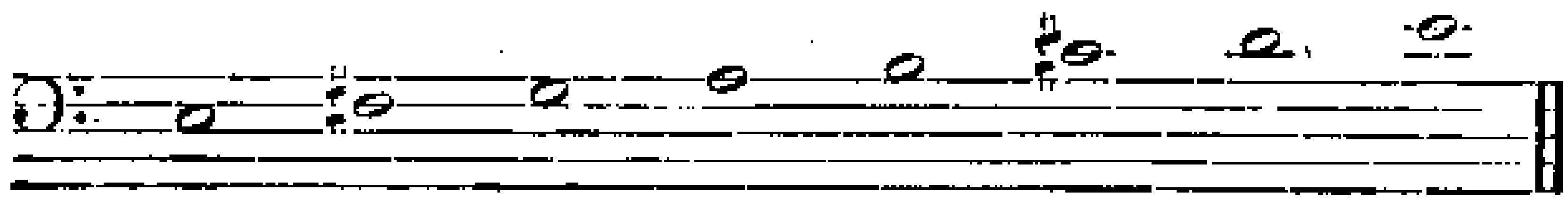
Mixo-Lydian Mode.



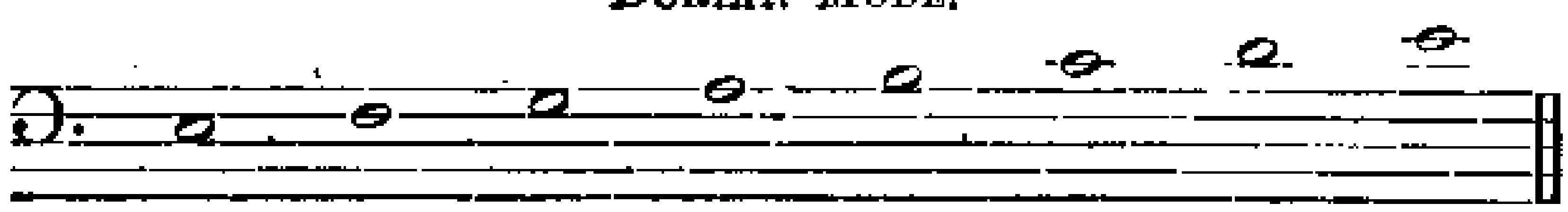
Lydian Mode.



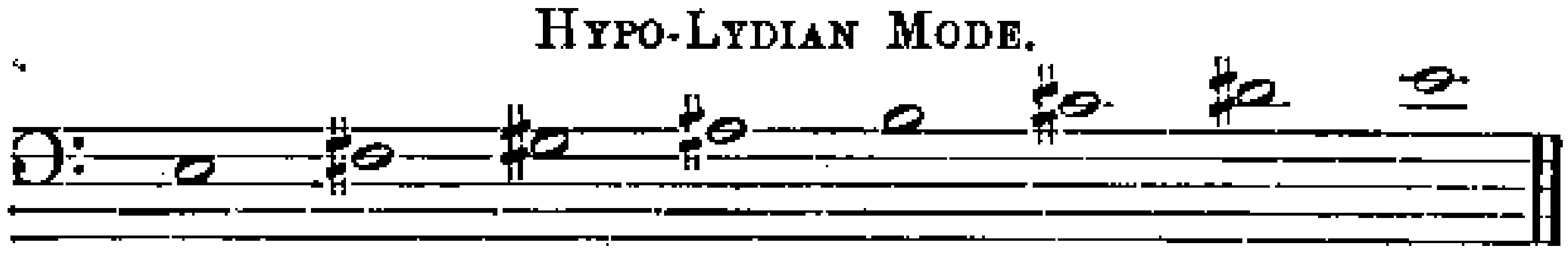
Phrygian Mode.



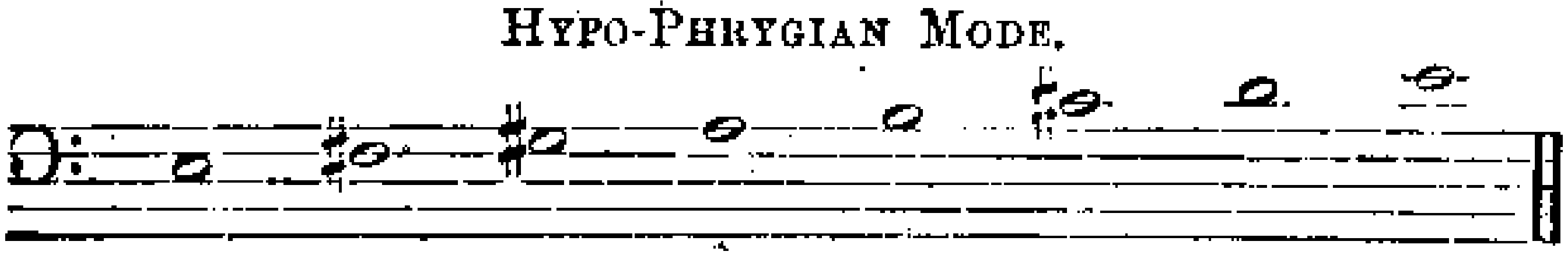
Dorian Mode.



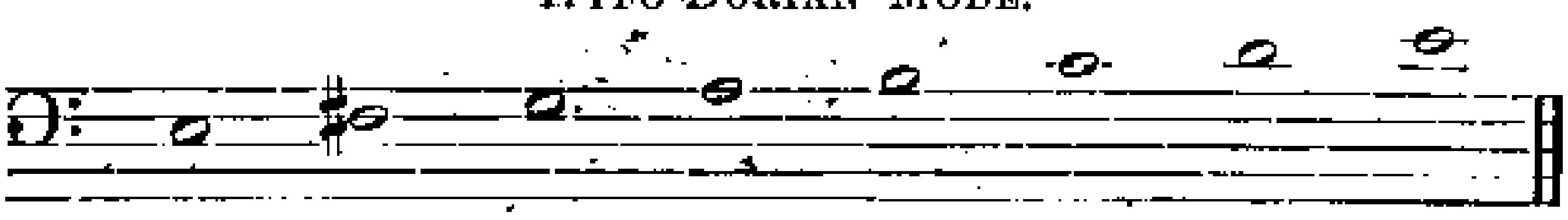
Hypo-Lydian Mode.



Hypo-Phrygian Mode.



Hypo-Dorian Mode.



It will be noticed that the three modes called Dorian, Phrygian, and Lydian, arise directly out of the divisions of the tetrachord having the same names, which have been mentioned on page 95. Thus—

	Dorian Octave form.	*Phrygian Octave form.*	*Lydian Octave form.*
Tetrachord	Tone	Tone	Hemitone.
	Tone	Hemitone	Tone
	Hemitone	Tone	Tone.
	Separating Tone.	Separating Tone.	Separating Tone.
Tetrachord	Tone	Tone	Hemitone.
	Tone	Hemitone	Tone.
	Hemitone	Tone	Tone.

These three varieties are supposed to be derived from the most ancient sources. There is no record of the invention of them; they were always treated as already existing, or rather as having belonged to the three peoples after whom they took their names.

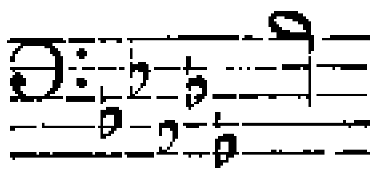
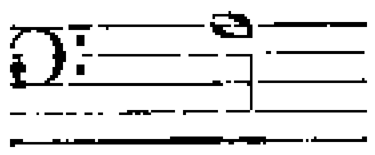
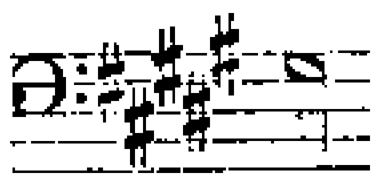
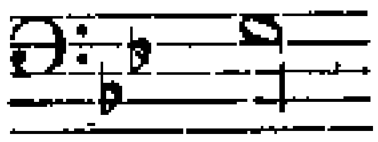
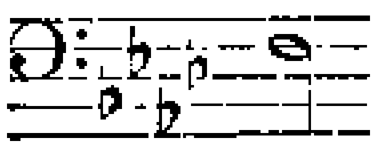
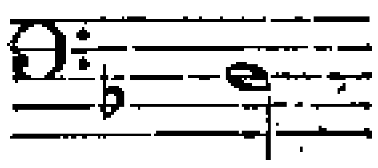
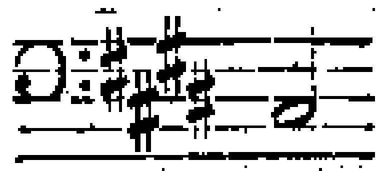
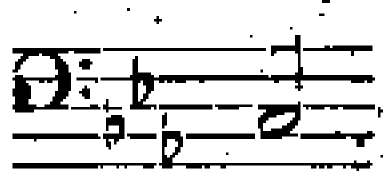
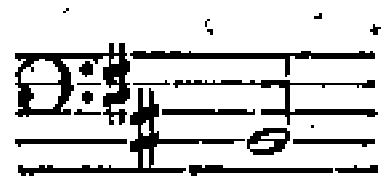
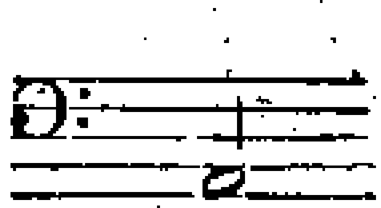
The other four varieties are less symmetrical, as each of them combines in itself two different tetrachordal divisions. Their origin is much later, and is matter of history.*

There appears reason to believe that in process of time a change came over the practice of the Greeks in regard to their modes. The varieties of octave-form became less used, and were at last limited to one, namely, the Hypo-Dorian, corresponding to our modern minor.

Concurrently with this arose a new system of a different kind, for the purpose of *transposition*. It was desired, for the sake of variety, to transpose the scale into different pitches, precisely as we may now take our minor scale in different keys. The later Greeks, therefore, proceeded to systematise this transposition; they had already, by dividing the tones in the diatonic scale, obtained twelve semitones in the octave, and they provided means for shifting the diatonic scale into any of these at pleasure.

As the octave-form was the same in all cases, they gave the system generally the name of *Σύστημα ἀμετάβολον*, or the *invariable* system, in contrast to the variable system of the octave-forms. The various transpositions were called *τόνοι* or *τρόποι*; each of them was treated as a different arrangement, and was given a different name. But, oddly enough, the *same names* were employed for this purpose as had before been used to distinguish the variable octave-forms. During the changes that went on, many alterations were made from time to time in this respect; but the system ultimately settled down into the shape shown in the following table:—

Table of the later Greek Transposing-Scales.

Pitch of the Proslambanomenos, or lowest note of the Scale.	Name given to the Scale at this Pitch.
	Hyper-Lydian.
	Hyper-Æolian.
	Hyper-Phrygian.
	Hyper-Iastian.
	Hyper-Dorian.
	Lydian.
	Æolian.
	Phrygian.
	Iastian.
	Dorian.
	Hypo-Lydian.
	Hypo-Æolian.
	Hypo-Phrygian.
	Hypo-Iastian.
	Hypo-Dorian.

It is to be understood that the entire diatonic scale of two octaves, represented on page 98, is transposed, so that the lowest note may have the pitch given in the left-hand column.[1]

The table, it will be seen, consists of three groups, each containing five tones or tropes; a middle or principal group, distinguished by the simple names; an upper group, each tone or trope being a fourth above the corresponding one in the middle, and distinguished by the prefix *hyper;* and a lower group, each tone or trope being a fourth below the corresponding one in the middle, and distinguished by the prefix *hypo.* The various notes of the scale, in each transposition, retained their usual names.

This system was used chiefly for instrumental purposes. Its introduction was gradual, but it appears not to have been completed, in the above systematic form, till after Aristoxenus, who wrote in the fourth century before the Christian era.

The change, however, from the early system of octave-forms to the newer one of transposed keys, was a change for the worse, as it abolished the real distinctive characters obtained by the former, and confined the variety to a mere change of pitch, the character of the succession of intervals always remaining the same.

The names given to the tones or tropes have caused much misunderstanding and mistake among later historians and writers on music, who have been puzzled to find the same names applied to series of notes which, on examination, proved to be essentially different in their fundamental arrangement. There has been also another cause of confusion. The Latin writers, through whom the Greek music was at first made known, in speaking of the *tonoi* or *tropoi,* called them *modes* (*modi*); a name which would have done very well had it retained its signification. But as

[1] These positions of the various scales are given by Burney and Fétis; Westphal considers they should each be written a major third lower, and should sound lower still.

it soon afterwards, when applied to the music of the Church, acquired a totally different meaning (that which it bears now), its application to the transposition system has become erroneous and misleading. Westphal has very appropriately used for the *tonoi* or *tropoi* the epithet *Transpositions-scalen*, or *transposing-scales*, avoiding the word *Tonarten* or modes, and so, in conformity with our present use of terms, it undoubtedly ought to be. When we speak of the "Greek modes," we ought to understand, not the later transposing system, but that of the earlier variable *octave-forms*, which alone satisfy the analogical meaning of the term.

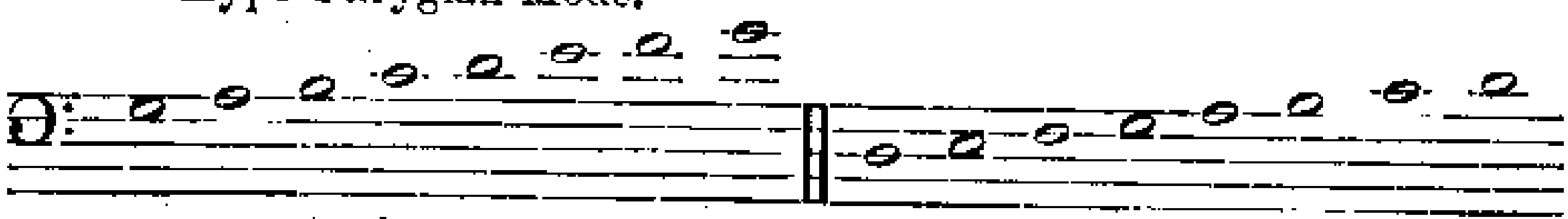
About the beginning of the Christian era, the celebrated astronomer and geographer, Ptolemy, proposed to go back to the original principle of the octave-forms; and his proposal appears to have found many partisans, particularly in the school of Alexandria. At any rate it bore such fruit that when music was adopted in the early Christian churches, although we know that the general arrangement of their scale came through the Romans from the later Greeks, yet they ignored the later system of transposing-scales, and went back to the more ancient and better models of the octave-forms. Ambrose, in the fourth century, adopted these, but lessened the number from seven to four, corresponding with those called Phrygian, Dorian, Hypo-Lydian, and Hypo-Phrygian respectively. For want of a better name these were called *modes*, although they had no analogy with the *tonoi* and *tropoi*, to which that name had been given by the early writers; and so arose the double meaning of the term[1] which has caused so much confusion. The complicated transposing system thenceforward disappeared altogether.

Gregory, a little later, added to the Ambrosian modes four others, constructed from them, which he called *Plagal*, distinguishing the Ambrosian ones by the term *Authentic*. The plagal modes were formed from the same notes as the

[1] See Note G in Appendix.

corresponding authentic modes, but beginning a fourth lower, and transposing some of the notes from the high octave to the lower one. Thus:—

Hypo-Phrygian Mode.



Authentic. Corresponding Plagal.

This invention of Gregory's had a peculiar significance in regard to the most important note of the scale, as will be explained in the next chapter.

The system inaugurated by Ambrose and Gregory went on for many centuries, but during this time more modes became introduced; and so much confusion at last ensued in the practice of them, that in 1547 a writer called *Glareanus*, endeavoured, by a careful examination of the musical compositions of his contemporaries, to reduce the scales to something like order.

Adhering strictly to the principle of the ancient Greek octave-forms in regard to the different arrangement of the intervals, he took six modes which he reckoned as authentic, and proposed to establish and confirm. In addition to these he also proposed to use six plagal modes formed upon them, making twelve in all, from which he named his work *Dodecachordon*. These modes he distinguished by Greek names, but by some confusion between the ancient and the later Greek appellations, he did not use the names which, according to the true or ancient Greek system, were originally appropriated to the modes in question. This was unfortunate, for Glareanus's names have been perpetuated down to the present day, while the true Greek ones are comparatively unknown.

Glareanus's twelve modes did not, however, hold their ground; for the general practice relapsed into the system of the original eight, as established by Ambrose and Gre-

gory; and when the Church modes are now spoken of, they are usually classified as first, second, &c., up to eighth.

The following table will show a comparison of the various modes, or octave-forms, according to their several appellations:—

Church Name.	Name given by Glareanus.	Original name of the corresponding Greek octave-forms.	Limiting notes of the octave, when expressed on the white keys of the pianoforte.
First Mode, Authentic	*Dorian*	*Phrygian*	D.
Second ,, Plagal of the 1st	*Hypo-Dorian*	None corresponding.	—
Third ,, Authentic	*Phrygian*	*Dorian*	E.
Fourth ,, Plagal of the 3d	*Hypo-Phrygian*	None corresponding.	—
Fifth ,, Authentic	*Lydian*	*Hypo-Lydian*	F.
Sixth ,, Plagal of the 5th	*Hypo-Lydian*	None corresponding.	—
Seventh ,, Authentic	*Mixo-Lydian*	*Hypo-Phrygian*	G.
Eighth ,, Plagal of the 7th	*Hypo-Mixo-Lydian*	None corresponding.	—
Modern major. No church mode corresponding	*Ionian*	*Lydian*	C.
Modern minor. No church mode corresponding	*Æolian*	*Hypo-Dorian*	A.
None corresponding	None corresponding	*Mixo-Lydian*	B.

The Ionian and Æolian authentic modes of Glareanus, corresponding to our modern major and minor, were excluded from church use, but were largely employed in music of a secular character.

CHAPTER X.

MODERN TONALITY.

WE may now go a step farther.

Taking the eight notes of any one of the Greek octave forms (or rather the seven notes, for the upper one is only a repetition of the lowest one), the question may naturally arise, Were all these notes of equal importance, or was there any one in particular that might be distinguished as the principal one?

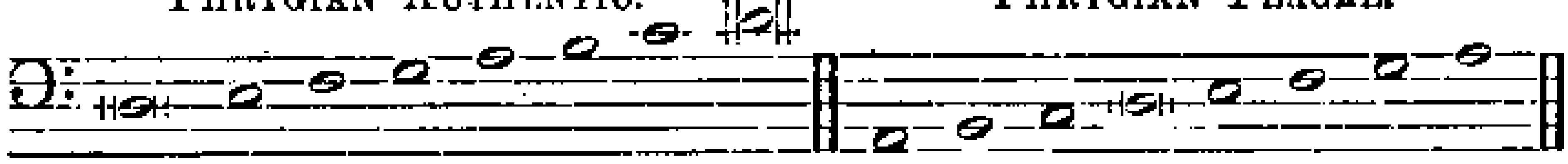
This question is suggested by the great prominence and importance of the *key-note* in our present musical system. It is natural to ask whether any such idea existed in the old music, and, if not, when and how it came into vogue?

In regard to the Greek music, we find a special importance given to the middle string, μέση. Aristotle describes it as influencing the intonation of the other strings, and adds that in all good compositions it was used the most frequently. It then becomes a question, what position the *mese* occupied in the modal scale or octave-form. Westphal (p. 108) infers, from passages of Ptolemy, that it was always the *fourth* above the lowest note; and he founds on this some ingenious speculations as to the construction of melodies and their harmonic treatment. Other writers give a special importance to the lowest note itself, in which they believe it was customary to cause every composition to end. And it is certainly natural to think that the lowest and highest notes of any octave-form, between which all the others were contained, should have been considered of special importance.

In the early ecclesiastical music, the reference to a principal note in the scale becomes somewhat more definite. In regard to the four original "authentic" modes or scales of Ambrose, we find the rule clearly established that melodies in which they were used should *end on the lowest note of the scale.* Hence this note became the important one, a sort of *tonic* to a certain extent analogous to ours, and in all probability this was the first dawning of our present tonal system.

This condition renders more clear the nature of the distinction between the *authentic* and the *plagal* modes, subsequently introduced by Gregory. Compare, for example, the Phrygian authentic and the corresponding plagal mode.

PHRYGIAN AUTHENTIC. PHRYGIAN PLAGAL.



In the former the important note, the final or tonic D, is the lowest note of the scale; in the latter it is the fourth note in ascending.

If now, in a series of eight consecutive notes, we consider, on the "authentic" principle, the lowest note to be the important one, or *tonic;* and if further we bear in mind the Pythagorean first landmarks of subdivision of the octave, namely, the *fifth*[1] and *fourth,* we shall be able to test the octave-forms of the Greeks, in regard to their applicability to such a division.

We shall find that one of them, the Mixo-Lydian, has

[1] It is worthy of remark that in the ancient church melodies we find, not only the most important note marked as a *tonic,* but also a distinct indication of another note next in importance to it. The melodies ended on the tonic, but in their course they used one note more frequently than others; from the *predominance* of this note it was called the *dominant,* and it was generally the fifth of the tonic, and it was of course the origin of the present note known by that name.

"Les tons du plain chant sont des formules de chant basées sur les échelles qu'on vient de voir, au moyen de certain note qui sert de repos, de point d'appui au chant (*finale*) et d'une autre note (*dominante*), qui, s'alliant de la manière la plus naturelle et la plus frequente aux formes mélodiques qui conduisent à la note de repos, charactérise aveo celle-ci la tonalité de l'échelle."—Fétis "Methode Elémentaire de Plain Chant." Paris, 1843.

The Church use of the dominant appears to be analogous to that of the Greek *mesē.*

an imperfect fifth, and another, the Hypo-Lydian, an imperfect fourth, both therefore giving imperfect results. These were late introductions, and but little is known of their Greek use.[1] Glareanus included one of them in his list, on theoretical grounds, but neither of them was much used in the Church when tonality began to assume importance.

The other five may all be considered good and proper tonal scales; they all agree in the characteristic that the main divisions of the octave are perfect, and they only differ from each other in the subordinate divisions, these differences giving the peculiar character to each mode.

The following diagram will show clearly the nature of the differences in question:—

Original Greek Names.	HYPO-DORIAN.	LYDIAN.	PHRYGIAN.	DORIAN.	HYPO-PHRYGIAN.
TONIC.	*(Modern Minor.)*	*(Modern Major.)*			
	TONE.	SEMITONE.	TONE.	TONE.	TONE.
	TONE.	TONE.	SEMITONE.	TONE.	SEMITONE.
FIFTH.	SEMITONE.	TONE.	TONE.	SEMITONE.	TONE.
FOURTH.	TONE.	TONE.	TONE.	TONE.	TONE.
	TONE.	SEMITONE.	TONE.	TONE.	SEMITONE.
	SEMITONE.	TONE.	SEMITONE.	TONE.	TONE.
TONIC.	TONE.	TONE.	TONE.	SEMITONE.	TONE.
			First Church	*Third Church*	*Seventh Church*

Out of these five tonal scales three have become obsolete, only two being used in modern music. The reason for this change is to be found in the introduction of *harmony*. About Glareanus's time, music began to take a rapid stride in advance by the genius of the immortal Palestrina. The practice of harmony had then become cultivated, and this, as it progressed, took such an important position as to make all other elements subservient to it.

The harmonic relations acted at once on the modes. It was found that some modes were better suited than others for harmonic purposes; and, on the Darwinian principle of the "survival of the fittest," these lived on, while the less suitable ones died away.

But, singularly enough, the modes that lived on into modern music were *not the Church modes*, but those which, as stated in the last chapter, had been employed in secular music. One of these, the Greek Lydian (Glareanus's Ionian) in particular, had been taken possession of by the Troubadours and other secular musicians of the Middle Ages; and this mode was held in contempt by the churchmen, who called it the *modus lascivus*, or wanton mode. Yet, when tested by the requirements of harmony, this proved to be the most useful of all, as it is now our *modern major* mode, in which the greater part of the music of the last two centuries has been written.

The modern minor mode corresponds to the Greek Hypo-Dorian. This also was not used in the Church, but it was well known in secular music, and particularly for national or popular melodies.[1]

Along with the harmonic element came in a much more perfect establishment of the predominant importance of the fundamental note of the scale, or *tonic*, as it came to

[1] Further explanations on the superiority of these two modes for harmonic purposes will be found in chap. xix., and in Helmholtz, pp. 378 to 380, 459 to 461, 464 to 467, 567.

be called. Compositions were not only made to end in it, but the harmonies were so arranged as to have continual reference to it, and so to keep it constantly in the mind as a sort of standard to control and regulate the whole. The influence of this principle became more and more prominent, until in the last century it became firmly established as one of the most essential elements of musical composition. It is difficult now for ordinary musicians to conceive even the slightest musical phrase otherwise than as identified with a particular key.

One of the best English writers on music, Mr. Hullah, has paid much attention to the history of this feature.[1] He estimates that the old form of tonality, that of the modes of the Church, copied from the Greeks, was in vogue till about 1600; that then came about one hundred and fifty years of *transition*, during which the feeling for harmony was gradually acting in the transmutation of the old system and the preparation of the new; so that it was not till about the death of Handel or the birth of Mozart that the modern tonality took firm root, and became established as we now have it.

It is strange to think that a feature which we now deem one of the most positive necessities of music should be only about a century old; but this is only another warning how careful we ought to be not to be misled, in arguing about the theory of music, by modern habit and education.

It is doubtful whether the imperative adoption of modern tonality is an unmixed good, for it cages us in a somewhat narrow circle. Even the minor mode we do not give its full scope, for in some respects it is altered to assimilate it to the major. (See Chap. XII.)

[1] See his "History of Modern Music," and "History of the Transition Period." Professor Macfarren also ("Lectures on Harmony," p. 26) mentions how "utterly regardless" Handel and Bach were of the peculiarity of the "sensitive note," on which the modern tonality chiefly hangs.

Many writers have advocated more variety in our tonal arrangements.

The following remarks by Hauptmann on this point are worth quoting:—

"Many of the choruses in 'Israel in Egypt' acquire an entirely peculiar colouring through the old modes in which they are more or less strictly written. We have already discussed how often, in modern music, the boasted richness of harmony is confined to the poverty of two chords, the tonic and dominant, which, notwithstanding all modulation into far-removed keys, only reappear transposed; whereas Bach, while remaining in one key, can find material enough to develop the richest variety by using not only these two, but all harmonies that lie in the scale. Something similar appears to me to exist in the distinctions between our modern major and minor and the old modes; the former lead to mere transpositions of one and the same series of notes, whereas the latter are, by the differences in the steps of their scales, entirely distinct from each other, and have each consequently a decidedly marked character. Handel has taken advantage of this—the chorus No. 11 being entirely Phrygian, No. 21 being mostly Dorian, so far as the treatment of the scale is concerned. This sort of thing ought not to be thrown aside as useless lumber; it might do good service in opposition to the insipid sentimentality of modern taste; it tends to enforce strength and power."—*Letters to Hauser*, vol. i. p. 7.

Helmholtz (to whom the subject of tonality appears to have great attraction) has investigated the characters and capabilities of the old modes at much length.

It is by no means impossible that composers of genius might some day open for themselves a considerable field for novelty and originality by shaking off the trammels of our restricted modern tonality; and that they might find scope for the development of the art in some kind of return to the principles of the ancient forms, which at present are only looked down upon as obsolete remnants of a barbarous age.[1]

[1] See further remarks on this subject in Note A, at the end of this work.

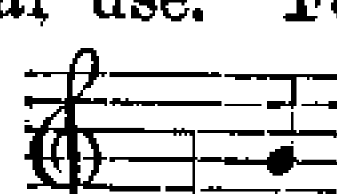
CHAPTER XI.

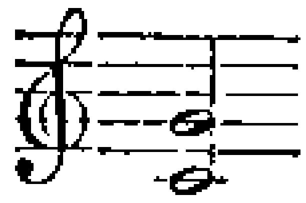
THE MODERN DIATONIC SCALE, AS INFLUENCED BY HARMONY.

In the last chapter the introduction of harmony has been alluded to as having had an influence in determining the modern modes. But it has done more than this; for harmony has acted also in modifying, in an important way, the positions of the notes of which the diatonic scale should be formed.

The nature of harmony generally will be discussed at length in the next part. But as its bearing on the scale must have a place here, it will be necessary so far to anticipate as to take for granted one or two of the most simple harmonic combinations.

It has been already explained that Pythagoras, in determining the notes of the ancient diatonic scale, took into account the relations of the notes to each other, defining these relations by the proportionate lengths of string necessary to produce the notes compared.

Now these relations are precisely what we now know as the relations of harmony, and thus we come upon the curious fact that the *principles* of harmony were, to a certain limited extent, known and applied centuries before harmony itself came into general use. For it is easy to understand that two notes, say  when sounded *successively* in the manner of a *melody*, may be governed by the same mutual relations as if they were sounded *together*,

thus,  in the more modern manner of *harmony.*

But when harmony became practised as a musical system, the relations between notes simultaneously sounded assumed much more importance; and thus the harmonic considerations, which existed to a considerable extent previously, had to be carried much farther. The principles of harmony now form the positive basis for fixing the exact places of the different notes of the diatonic scale.

There is also another modern element that, from its very nature, must enter largely into the question, namely, that of *tonality.* The fact that one note of the scale is much more important than any of the others, must of necessity give that note the prior consideration in harmonic relations, it being the point of reference of the whole.

Hence we get the rule, as regards the modern diatonic scale, that

Every note of the scale must have, as far as possible, concordant harmonic relations to other notes; and in determining these, the relations to the tonic or key-note are the more important.

It will be desirable now to re-examine the diatonic scale by the light of this rule, and to see how far the Greek determinations of the positions of the notes meet the requirements of modern harmony.

The most convenient method of doing this is by measuring the intervals between the several notes according to the method of logarithms described in chap. vi., by which the magnitude of each interval can be expressed in simple numbers.

And we may also now apply the plan briefly alluded to at the end of that chapter, namely, that of representing the intervals *graphically.* This is a most useful method in the higher class of musical investigations, from the easy and definite manner in which it enables relations, usually

considered complex and obscure, to be presented to the mind; and hence it will be well to explain it somewhat fully, in order to make it perfectly clear and intelligible.

If we think a little, we shall find that we have a natural tendency to compare the positions of musical notes with positions in space. It is not clear that there is any real or physiological connexion between the two things; but it is certain that the idea of such a connexion has, somehow or other, become implanted in our minds.

For example, we call a note with rapid vibrations a *high* note, and one with slow vibrations a *low* note, clearly referring them to comparative positions in space. These expressions, high and low, are purely arbitrary and conventional; there is no natural justification for them; but they have existed almost ever since music took a definite form, and they clearly illustrate the analogy here insisted on.

Now further, if a rapid-vibration note is called high, and a slow-vibration one is called low, it follows that the musical idea of *distance*, or what is called the musical *interval*, between the two notes may be considered as having an analogy in our minds with the *interval in space* between the high position and the low one; and we can easily imagine that if the musical distance between the two notes is greater, it may be represented by a greater interval of space, and *vice versa*.

In other words, it is possible, and consistent with ideas already existing in our minds, that representations of musical intervals should be made for the *eye*, so as to convey ideas of comparative magnitude precisely analogous to the impression which these intervals make on the *ear*.

This is the *graphic* method of representing intervals, and it is proposed to apply it, in this and the following chapter, to the illustration of the nature of the modern scales, a purpose for which it is particularly well adapted,[1]

[1] This adaptation was published by Sir Frederick Ouseley's work on

as representing the minute differences of intonation more clearly than by any verbal descriptions.

The idea of such a representation of the scale is embodied in the very word itself, for our term scale is derived from the Latin word *scala*, which means a ladder or staircase; and this of course implies that the intervals of *space* between the various steps of a ladder have been considered, from very remote antiquity, as corresponding with the *musical* intervals between the various notes of the scale.

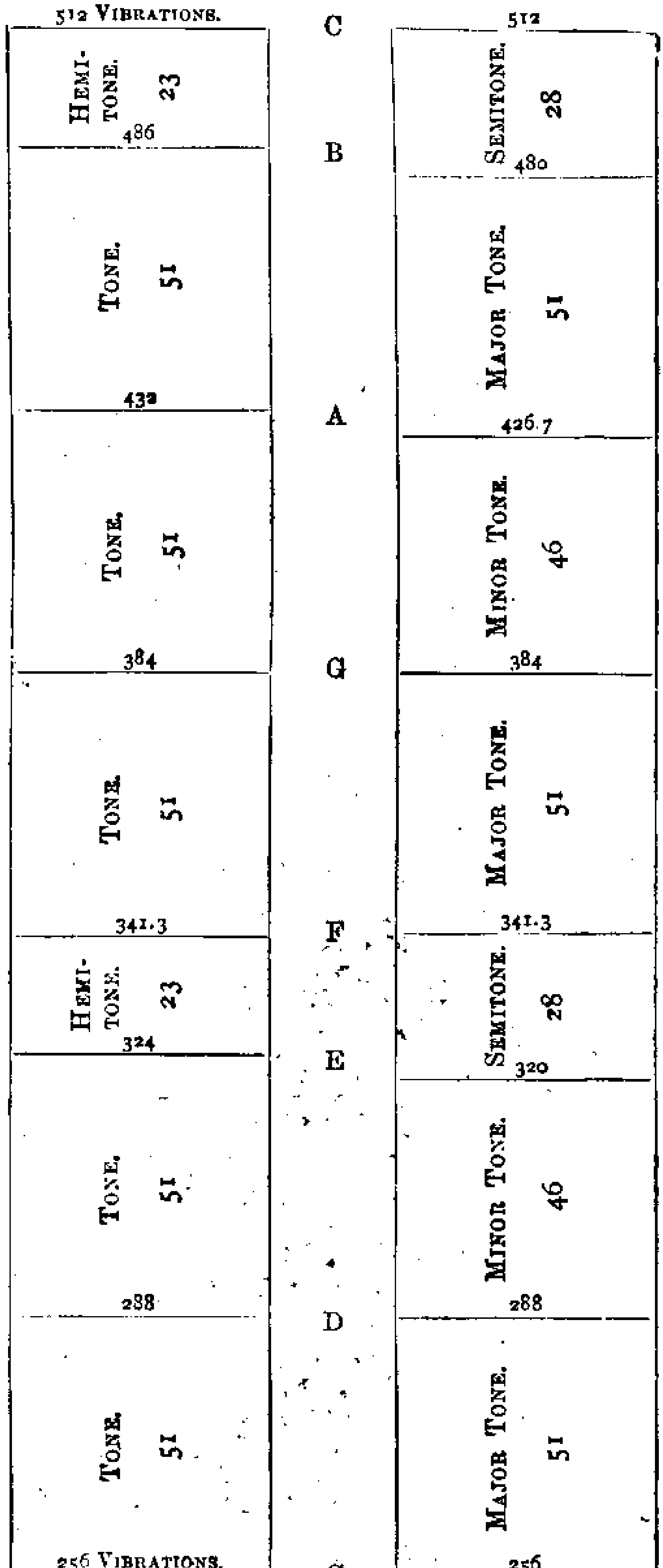
The mode of preparation of such a graphical scale is very simple, when the various intervals are musically defined, inasmuch as nothing more is necessary than to lay down, from any convenient scale of equal parts, the *logarithmic* value of the intervals, as explained in chap. vi. The relative positions thus determined will then offer to the eye a representation of the scale precisely corresponding to the impression produced on the mind through the ear, and perfectly accurate even to the most minute shades of intonation.

The comparative diagram of the Greek and modern diatonic scales, given on page 133, is prepared in this way.

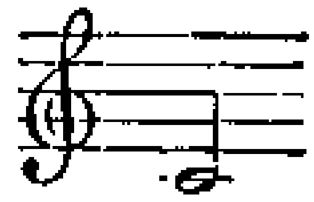
The left-hand figure represents the Greek diatonic scale as settled by Pythagoras, and the right-hand one is the modern scale as determined by the harmonic relations. The two may thus be easily compared, and the differences between them rendered easily appreciable. These differences are but slight, but as the principles on which they depend are very important to the theory of music, it is desirable to study them with some care.

Let us now, therefore, with the aid of this diagram re-examine the diatonic scale of the Greeks, and see how far its notes are affected by their harmonic relations to each other, and particularly to the *tonic* or key-note, which forms in modern music the basis of the whole. We will follow the Pythagorean construction, taking as the sim-

THE GREEK DIATONIC SCALE, AS USED FOR MELODY. (LYDIAN OCTAVE FORM.)



THE MODERN DIATONIC SCALE, AS INFLUENCED BY HARMONY.

plest example a scale with the key-note of C, and adopting the Greek Lydian, corresponding with our modern major mode. For the sake of assigning definite positions to the notes we will take the C  = 256 vibrations per second, as the lowest note of the scale.

The scale is bounded by the most important interval in music, that of the *octave*, giving C = 512 vibrations, the logarithmic value being 301. This is a true and perfectly concordant harmonic interval, which therefore remains faultlessly applicable to the modern scale.

The most important intermediate note in the scale is G, forming with the key-note C the interval of the fifth. This was laid down by Pythagoras as his chief division to a ratio of 3 : 2, giving a logarithmic value = 176, and producing a note with 384 vibrations. This also is a perfectly good concordant interval, which cannot be improved, and it therefore remains intact in the modern scale.

The same may be said of the second main Pythagorean division F, the fourth (ratio 4 : 3, logarithm = 125) giving a note of $341\frac{1}{3}$ vibrations. This also forms a good harmonious concord.

Thus we see the main divisions of the Greek diatonic scale, the octave, the fifth, and the fourth, agree precisely with those of modern music.

We must now proceed to fill in the subordinate divisions.

Take first the note D, which on the Greek division is a *tone* above C. This interval has a ratio of 9 : 8, or a logarithmic value of 51, and giving a note of 288 vibrations. This is too near the key-note to form a concordant relation with it, but a little examination will show that the note D thus fixed forms the concordant interval of a perfect fifth with the G below, the note G being the next in importance

to the tonic C. This note D therefore stands, on this justification, in our modern scale.

By taking another *tone* above D we get the next note on the Greek scale, namely, E, with 324 vibrations.

Here we come upon a difficulty, for by comparing this with the key-note C we find an inharmonious or discordant relation, the value of the interval being the ratio of 81 : 64, or the logarithm 102. But when we come to study the principles of harmony, we shall find that there is a harmonious or consonant note *very near* this, namely, at the interval expressed by the ratio of 80 : 64 (5 : 4), or the logarithm 97, giving a note with 320 vibrations. Hence, consistently with the principle that the relation to the tonic must have the primary significance, we prefer, in modern music, to put the third note of the scale in such a place as will produce this relation, or, in other words, we make it what is called a *true* major third.

The position of E thus obtained is shown by the line on the right-hand diagram, which, it will be seen, is a little lower than the one on the Greek scale.

Of course this causes some alteration in the two intervals or *tones* of which the third is made up. We might reduce either of them, but the D is an important note, and it is desirable to keep it as it was, as it forms a true fifth to G, and hence we reduce the distance from D to E. This would come out by calculation = 10 : 9 : expressed by the log. = 46. It is called a *minor tone.* The major tone, C to D, is 9 : 8 = 51. The difference between them, called a *comma,* has the ratio 81 : 80; log. = 5 nearly.

The position of the E as we first had it, *i.e.*, made up of two equal major tones, gives what is called the *Pythagorean third.*

It is worth while mentioning that the inharmonious nature of the Pythagorean third was found out by the later Greeks. One Didymus about the commencement of the Christian era proposed the very alteration we have just described; and it was again insisted on by Ptolemy

about a century later, and was adopted in the later Greek scales. It says much for the delicacy of the Greek sense of music that they remarked this inharmoniousness, which would pass without notice by the ears of many modern musicians.

We may now go on to fill up the subordinate divisions of the scale above G. Following the Pythagorean divisions, by setting off two major tones above G, we get the two notes, A = 432 vibrations, and B = 486 vibrations.

In regard to the first of these, A, if we compare it with the upper tonic C, we find it gives an interval, which by calculation comes out = 32 : 27, log. = 74, being inharmonious and discordant.

But there is an interval very near it, namely, the *minor* third, which is consonant and harmonious, and which has a ratio of 6 : 5, log. = .079. This gives a note with 426.7 vibrations. And therefore, on the same principle as before, the A is put a little lower, where it will form this relation; and it then also forms with the lower C another consonant interval, the major sixth, ratio 5 : 3, log. = 222.

Looking next to the seventh note, B, it is too near the tonic to form any consonance with it; but we may compare it with the next note in importance, namely, G, and we find it makes with it a Pythagorean or inharmonious third. Hence we must make the same correction as we did in the case of the E, by lowering it one comma, which makes it a true third to G, and gives a note with 480 vibrations.

The nature of these several changes will be obvious by a comparison of the two diagrams. The intervals between E F and B C are each called a *diatonic semitone,* ratio 16 : 15, log. = 28. The old Greek hemitone between the same notes was = 23.

We have now determined the scientific positions of all the seven notes of the modern diatonic scale; and if we compare them with each other we shall find that for the

most part the harmonic relations between them are properly consonant, thus—

C to E is a true major third	= 97
C to F is a perfect fourth	= 125
C to G is a perfect fifth	= 176
C to A is a true major sixth	= 222
C to C is a perfect octave	= 301
D to G is a perfect fourth	= 125
D to B is a true major sixth	= 222
E to G is a true minor third	= 79
E to A is a perfect fourth	= 125
E to B is a perfect fifth	= 176
E to C is a true minor sixth	= 204
F to A is a true major third	= 97
F to C is a perfect fifth	= 176
G to B is a true major third	= 97
G to C is a perfect fourth	= 125
A to C is a true minor third	= 79

Here, therefore, within the compass of one octave are found no less than sixteen perfectly consonant harmonic combinations, whereas in the original form of the scale less than half the number existed.

But even in the modern scale all the intervals are not perfectly consonant. Take, for example, the fifth from D to A; this will be found = 171, which is out of tune, being one-fifth of a semitone too flat. If we were to raise the A, we should put it out of tune for the subdominant chord F, A, C; if, on the other hand, we were to lower the D, we should spoil the chord of the dominant G, B, D; and as both these chords are of such importance to the tonality, it is better to retain them pure, leaving the error in the less important fifth D, A.

We shall also find that the interval from D to F is not a true minor third, being = 74 instead of 79, or one-fifth of a semitone too flat. This also cannot be remedied without spoiling intervals of more importance, and we are obliged to put up with a bad minor triad on the second of the scale, both the third and fifth being wrong.

Two remarks, of theoretical importance, arise out of this imperfection.

In the first place, in these out-of-tune relations between D, F, and A, we come upon the first and simplest of the difficulties in the way of getting what is called *just or true intonation* on keyed instruments, *i.e.*, a theoretical perfection in all the intervals when notes of the scale are combined in harmony. It is clear that no instrument with seven fixed notes in the scale can be always *in tune* for that scale, *i.e.*, can have all its combinations in perfect harmony. For this purpose we must have some of the notes *variable in position;* or, which amounts to the same thing, we must have more notes than seven—namely, alternative notes for D, F, or A. Other difficulties of the same nature will develop themselves to a much larger extent in the next chapter.

The next remark that arises out of these imperfections is, that they gave a strong corroboration of the view expressed in chap. viii., that the diatonic scale is a conventional and artificial series of notes, and not, as many people suppose, one dictated by any imperative natural, physical, or physiological laws. If it had been so it might have been expected to be perfect, whereas it is essentially imperfect by its very nature and construction. It is true that, as we have seen, it lends itself easily to certain naturally harmonious and pleasant combinations, and this is probably all that can be said in its favour.

CHAPTER XII.

THE CHROMATIC SCALE—THE SCALES OF THE MINOR MODE.

WE now come to another element in the scales used for modern music, *i.e.*, the *chromatic notes.*

The diatonic scale, of which we have been speaking exclusively hitherto, is represented by the *white* notes of the piano; the black notes represent additional sounds, which, when used in conjunction with the others, belong to what is called the *chromatic scale.*

These additions are very ancient in their origin. They were used to some extent by the Greeks. Sometimes when a diatonic progression consisted of a tone, they altered it to a semitone, just as we alter the distance F G, to F♯ G. In fact, systems of scales were formed in which these alterations occurred; and from some idea that such changes had an analogy to colouring, they called this kind of music the *chromatic* genus, from which our term comes.[1]

In the early ecclesiastical music, the diatonic scales used were also subject to occasional chromatic alterations. These changes were, however, seldom written in the music;

[1] They also went further, for as they found that even the semitone could be divided into smaller parts appreciable by the ear, they introduced quarter-tones. This was called … enharmonic genera will be found on page 95. They did not correspond to the same terms as applied in modern music, but they show that this nation had carried their study of …

they were left to be done by the singers, either according to tradition or as their fancy might direct.

This state of things continued till about the fifteenth century, when the use of harmony began to gain ground, and the sense of tonality became more developed, accompanied by efforts at modulation. This led to the much more copious and definite use of chromatic changes, and at last to the full chromatic scale, which appears to have come into use in the sixteenth century.

A chromatic note is usually supposed to be produced by taking a certain natural note of the diatonic scale, and altering its pitch by *sharpening* or *flattening* it as may be required.

This plan (which has almost amounted to a definition of a chromatic note) has been dictated by the exigencies of the musical notation; but it has no natural justification. The note F♯ has no sort of connexion with the note F♮; nor has B♭ any connexion with B♮. They are perfectly distinct; and if the means of notation allowed it they ought to have independent names and independent symbols.

We cannot rectify this now, but the imaginary connexion has been the source of much misunderstanding and error in musical theory, and it is right that all earnest students should dismiss it from their minds.

What we have to do here is to *determine the position* of the chromatic notes in the scale, in the same manner as we have determined the diatonic notes.

But this determination involves more difficulty. We must, in studying the theory of musical scales, avoid being misled by the simplicity of our pianoforte keys. We know that on this instrument C♯ and D♭ are represented by the same note, which is situated midway between C and D. It requires but little musical education to be aware that this is not correct; it is only a compromise,

but it requires a great deal more knowledge to be able to decide *precisely* whereabouts C♯ and D♭ should be, and what the two notes really mean; and even musically educated people have a confused and indefinite, and indeed often an erroneous, notion of the exact nature of the difference between them.

To solve this problem we must go to the root of the matter and inquire *what the chromatic notes are for? What purpose in the musical system do they serve?* Much confusion has arisen from a want of proper consideration of this point; and, indeed, it is doubtful whether the matter has ever received from theorists the attention it demands.

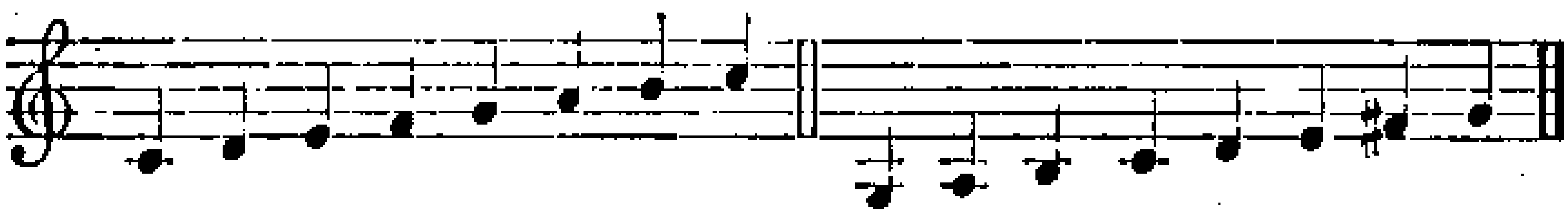
The solution of the problem, which involves some difficulty, appears to be as follows. The chromatic notes are used, in modern music, for *two distinct purposes,* which are so separate and dissimilar in their nature, as to lead to different conditions for the notes themselves, according to which purpose they are required for.

The first use, and undoubtedly the principal one, is for the purpose of *modulation.* This is an element consequent on the introduction of the modern tonality. The ancient varieties of mode being now out of use, composers are driven to give variety by changing the Lydian tonic on to a different note, and when this is done, the original scale becomes insufficient; new notes have to be added which did not exist in the original key.

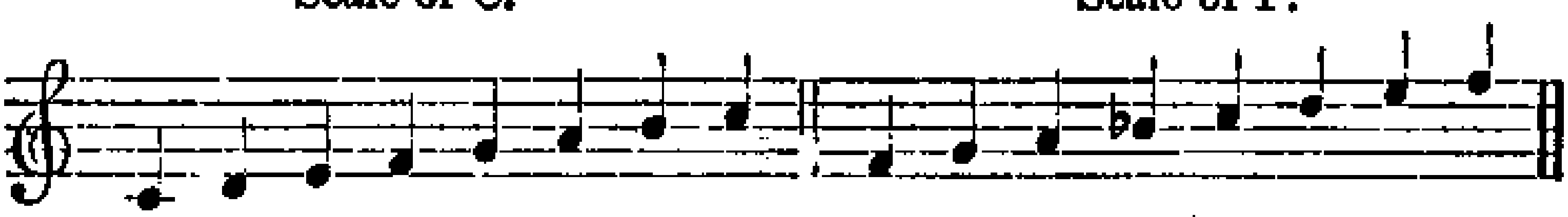
Suppose, for example, that after using the scale of C, it is desired to make G the key-note: taking the same intervals as before, it will be found that one of the notes of the former scale—namely, F—is useless, and that we want a *new note,* lying between F and G, to form the seventh of the new scale.

Now this note has, as we have said, no connexion whatever with the previous F; but for simplicity's sake, and in order to avoid introducing a new symbol, it is cus-

tomary to assume the fiction that the F is *raised* or *sharpened*, which operation is denoted by putting the sign of a sharp (♯) before the note, thus—



Again, suppose the key be changed to F, the note B becomes useless, and we want a new note between B and A to form the fourth of the new scale. This is represented by the fiction of *lowering* or *flattening* the B, which operation is denoted by putting the sign of a flat (♭) before it, thus—



These arrangements are familiar enough, as a part of ordinary musical education.

Now, there can be no mistake or difference of opinion as to *where* the new note, in either of these cases, should be. The new scale we want must be similar in construction to other diatonic scales; in fact, the new notes lose their chromatic character, becoming strictly diatonic; and this determines their position with absolute certainty.

The F♯ for the scale of G must correspond with the B in the scale of C; *i.e.*, it must be a *true major third above D*. And, similarly, the B♭ for the scale of F must correspond with the F in the scale of C; *i.e.*, it must be a *perfect fourth above F*.

These determinations, it will be observed, depend on the harmonic relations between the various notes of the scale, as explained in the last chapter; and they are imperatively fixed by the modern use of tonal harmony.

Here, therefore, we have one clear mode of determining

the exact place of chromatic notes, namely, by the HARMONICAL use of them.

But there is another purpose to which they are applied.

In the progress of music to its modern form, its first and simplest element, *melody*, has undergone a considerable change. Musical melody is no longer what it once was, a simple series of slow notes, but it admits, in its modern form, of *ornamentation*, often carried to a considerable extent, and very elaborately.

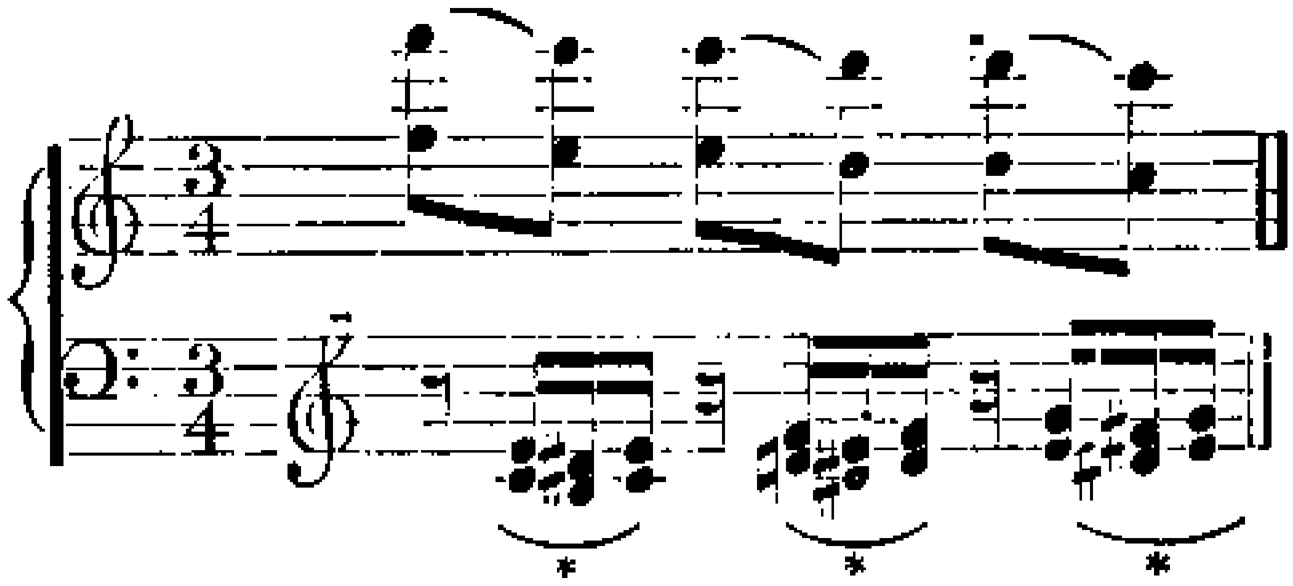
Now, in order to increase the scope of such ornamentation, it has become a practice to use other notes than those of the diatonic scale; and as the introduction of these notes is rather *accidental* than essential, the notes are expressly called by the name of *accidentals*. But as, in consequence of the limited nature of our notation, there is no means of expressing such notes except by the same fiction we have already mentioned, namely, that of the diatonic notes next to them being *sharpened* or *flattened*, they must be denoted by this kind of symbol.

These accidental chromatic notes, therefore, *look* like those previously described; but in reality they differ from them in nature altogether, inasmuch as they *involve no change of key*, and form no part of any new harmonic combination. In the former case they are *essential to the structure* of the composition in which they occur; in this case, they are merely *embellishments* superadded, just as an architect adds decorative ornaments to the substantial parts of his building.

This is what should be called the MELODIAL use of chromatic notes, and it may advantageously be illustrated by two examples. The asterisks show the chromatic embellishments.

MOZART.

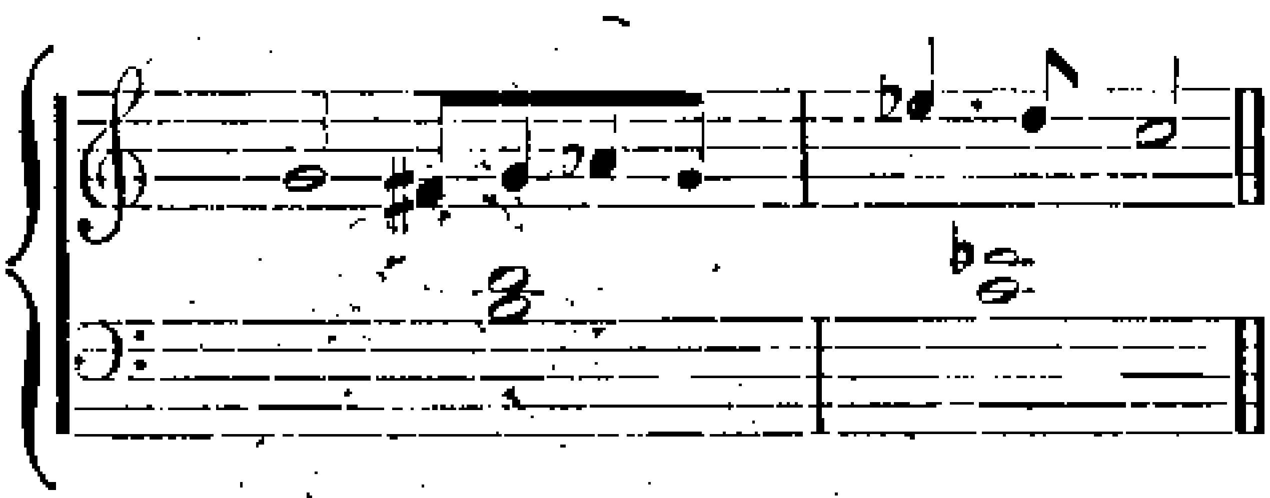
BEETHOVEN.



It will be seen that in neither of these examples do the chromatic notes involve any change of key; and, consequently, in no case does any chromatic note form a part of any new diatonic scale.

Let us then repeat our inquiry, Where should the chromatic notes be if used for this purpose?

The answer is a very simple one: in this case it does not much matter whereabouts they are. There is no logical reason why they should be in *any* particular place. A few examples will illustrate this proposition. Take such a passage as this—



which contains two accidentals, F♯ and A♭, used as melodial ornaments to the G. If the passage were played on a pianoforte or clarionet, or other keyed instrument, these must, of course, be played on the fixed notes used for general purposes. But if taken by a violin-player or a singer, who was unfettered as to their position, it is probable that his judgment and feeling would lead him to make them both *very close* to the G, *i.e.*, the F♯ only a very little below it, and the A♭ only a very little above it; indeed, in violin playing, this method of placing chromatic notes amounts to a rule.

Other cases would be treated differently. For example, if a violin player had to execute a passage containing what is called the *chromatic scale*, or a part of it, thus—

his feeling (which, if a good player, ought always to be his guide consistently with the structure of the music) would no doubt lead him to divide the tones *equally*, for the sake of making equal steps in his run.

Now, taking the note F♯, we have arrived at three different places for it.

1. The position determined by its harmonical use; namely, a major third above D, which brings it not quite half the height between F and G: assuming F to have $341\frac{1}{3}$ vibrations and G 384, then F♯ on this principle will have 360 vibrations.

2. The ornamental melodial position, which gives it an indeterminate place, very close to G; and this note having 384 vibrations, the F♯ may be put at 375 to 380.

3. The equally-divided melodial position, half-way between F and G; this will be about 362 vibrations.

This shows that we may legitimately have different places for the chromatic note F♯, according to the objects for which it is intended.

It will further be seen, which is the most important thing for our present purpose, that the *melodial* position is *indeterminate*, depending, not on any strict law or rule, but on the taste or fancy of the player or singer. It is clear, therefore, that this latter mode of determination can be of no use in *fixing* any values for the notes of the chromatic scale. This must be done by the *harmonical* method, which has the advantage of fixity and definiteness,

every note so determined having a positive place capable of being easily ascertained.

Let us proceed, therefore, to determine a series of chromatic notes on the harmonical principle, *i.e.*, a series of notes which are necessary in order to establish new diatonic scales. We will take a series of such scales, and see what chromatic notes they give rise to.

The first is the scale of G, already mentioned. This requires an F♯, which must be a major third above D, giving 360 vibrations per second.

Secondly, we may take the scale of D, which requires a C♯, a major third above A, giving 533.4, or for its lower octave = 266.7 vibrations.

Next, the scale of A requires a G♯, a major third above E = 400 vibrations.

Similarly the scale of E requires a D♯, a major third above B = 600 vibrations, or for the lower octave = 300.

And the scale of B requires an A♯, a major third above F♯ = 450 vibrations.

We might adopt a similar method in determining the *flats*, by taking B♭ as given by the new scale of F, and so on; but there is a simpler way of obtaining them by more direct harmonic relations.

E♭ should make a minor third with the key-note C, giving 307 vibrations.

A♭ should make a minor sixth with the same note, giving 409.6 vibrations.

B♭ is a minor third above G, giving 461 vibrations.

G♭ is a major third below B♭, giving 368.8 vibrations.

We might go further and get more sharps and flats, as E♯, B♯, C♭, F♭, and so on, but these are sufficient for our present purpose, as comprising the most common notes in the chromatic scale.

These notes are inserted in their proper places on the diagram in the Plate, which has been carefully prepared by the graphical method described on pages 131 and 132

But we now come in contact with the difficulty alluded to in the early part of this chapter, which is really an important one, illustrating forcibly the remarks made about the uncertain nature of the chromatic scale.

The diagram and the calculations will show that comparing the notes called sharps and flats, the latter, *i.e.*, the flats, are always the *higher* of the two. For example, D♭ is higher than C♯, G♭ is higher than F♯, A♭ higher than G♯, and so on. Now this is directly contrary to the teaching and practice of the violin, which is the instrument *par excellence* of true intonation. It is one of the most positive instructions to violin students that C♯ must be the nearest to D, and D♭ the nearest to C.

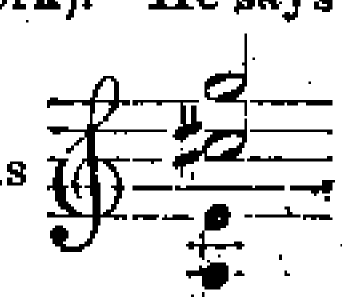
Berlioz, no mean authority, considered the discrepancy so important as to throw doubt on the whole acoustical system of harmonic relations,[1] and an excellent little book on the elementary principles of violin playing, lately published under the sanction of no less a personage than Herr Joachim, embodies the instruction as to the relative position of the two notes in unequivocal terms.[2]

[1] Traité d'Instrumentation, article "Concertina," p. 287.

[2] Die Grundlage der Violin-Technik, von Karl Courvoisier. Berlin, 1873, pp. 20, 21.

Cis ist Leitton in D-dur, und schliesst sich sehr eng an D. *Des* dagegen Dominant-Septime in As-dur, und schliesst sich eng an die Terz C.

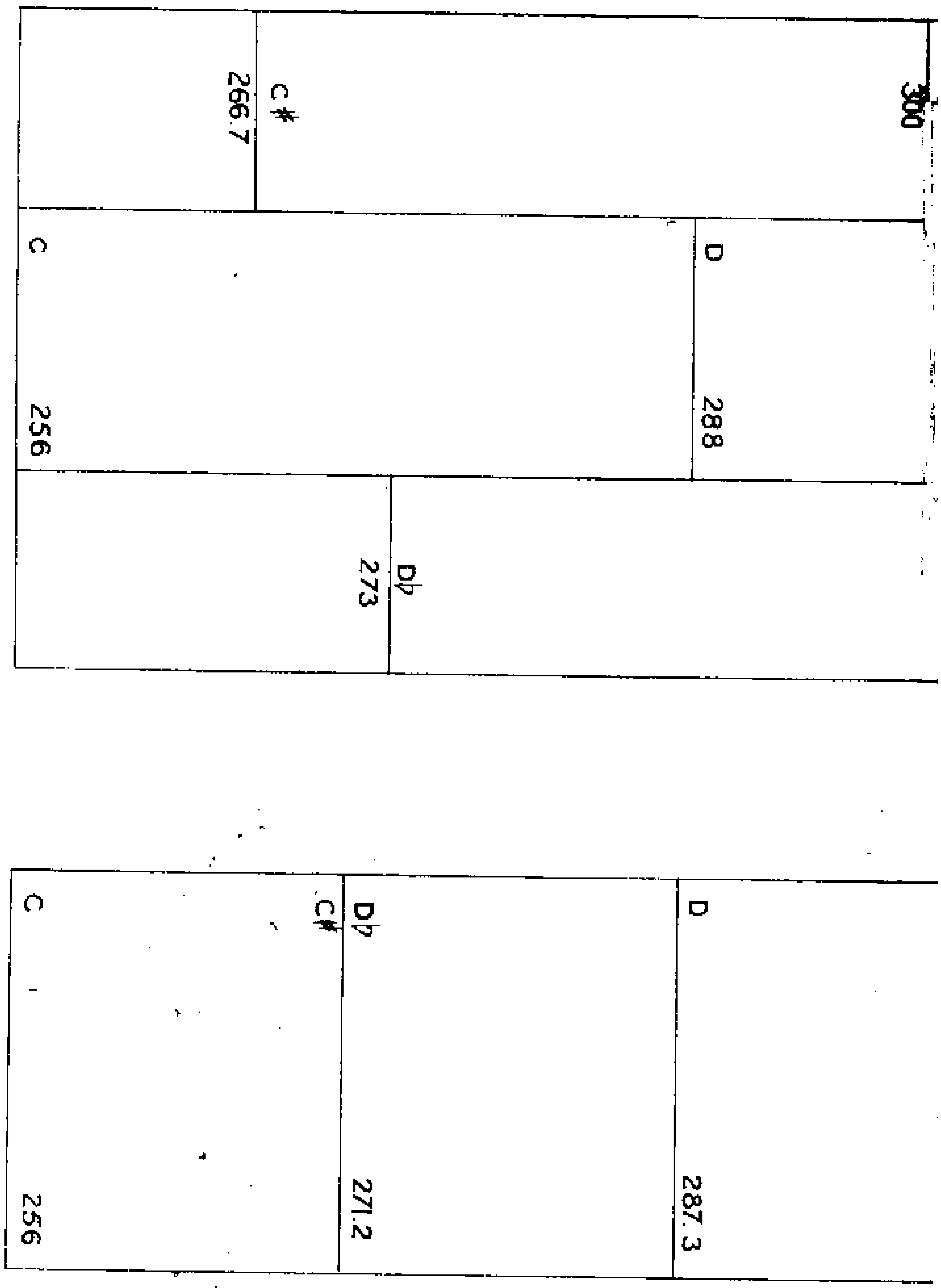
The author adds a very curious attempt to prove this on acoustical principles, founded on the well-known resultant sounds of Tartini (explained in chap. xvii. of this work). He says that if the two minims



are sounded together, with the C♯ high, the two crotchets will be heard as resultants, while if they are sounded with D♭ low, the resultants will be changed as shown

whence he draws the conclusion that the high position is the right one for C♯ and the low one for D♭.

It is true that if, with the upper G, 768 vibrations, we take another note of 555 vibrations, we shall get the low A, 213 vibrations, as resultant; and if with the G we take a flatter note, 538, we shall get the low B♭, 230, as resultant; but this does not prove the upper note to be C♯ and the lower one D♭. This is a mere fancy, without any foundation. If the C♯ as belonging to the scale of D, has any harmonious meaning whatever, it must mean the major third above A, which gives 533⅓ vibrations; while the D♭ must mean on the same principle a major third below F, giving 539 vibrations.



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This is a very serious difficulty; for, on the one hand, it would be out of the question to ignore the opinion of well-educated instrumentalists, such as Berlioz and Joachim; while, on the other hand, the principles on which these harmonic relations are constructed are so simple, and have been so clearly proved, both by theoretical and practical considerations, and by every investigator, from Pythogaras to Helmholtz, that it would be equally out of the question to controvert *them.* It does not appear that any attempt to explain or reconcile this curious discrepancy has hitherto been made; but it is quite capable of being satisfactorily accounted for.

The explanation is found in the fact of the *double meaning* and *double use* of the notes in the chromatic scale, namely, their *harmonical* and their *melodial* signification.

It must be recollected that the violin is essentially a *melodial* instrument; and the whole secret of the difficulty lies in the fact that the violinist looks on chromatic notes in their melodial aspect, and ignores that of their harmonic bearing, as foreign to his instrumental object. Accordingly, if a violinist is asked to give a reason why he makes G♯ closer to A than to G, he will think little of the *harmonical* relations of the note; he will regard more prominently its melodial character. He will say that G♯ is the *leading note* ascending to A, and (from some feeling of which it is difficult to give the reason) requires to be *very near it;* while in descending from A♭ to G, the same proximity is required in the other direction.

But these positions of G♯ and A♭ are the artificial and indeterminate ones, and are no guide for the more exact places of the notes as they would be required for harmony. And there is the strongest reason to believe that if a first-rate violinist were playing these notes in *sustained harmony,* —*e.g.,* the G♯ with an E, or the A♭ with a C—his ear would lead him to play the notes exactly in the theoretical positions, and altogether at variance with the above-mentioned melodial rules. We may safely doubt whether

such a player as Joachim could ever bring himself to play a major third out of tune, whatever his violin instruction book might say.[1]

To return to the chromatic scale. The notes as fixed on the diagram will provide for the diatonic scales of eleven keys—namely, C, G, D, A, E, B, F, B♭, E♭, A♭, D♭—and they give seventeen different notes in the octave; to get all the chromatic notes required for modern music, we ought to have gone still further.

But even with the notes we already have, we get into a difficulty; for if we examine the various new scales we have nominally provided for, we shall find many places where the harmonic relations between the different notes of the same scale are not true. In order, therefore, to get perfectly just intonation in all the keys, we must, in addition to the seventeen notes actually drawn, have many of them in duplicate or triplicate. This enormous difficulty has exercised the science and industry of many eminent

[1] The following remarks in Hauptmann's letters illustrate this point:—

"An animated intonation (on the violin) is just as little mathematically true as an animated time-keeping is strictly according to the metronome. On this account it is so difficult to play the violin with the piano, not on account of the equal temperament, as the learned believe, but because certain persons will not give way from their fixed and stereotyped ideas whether the note be a leading note or a minor ninth. It is very easy to calculate that, as against C, C♯ is lower than D♭; but when I [Hauptmann was professionally a violin player] use C♯ as a leading note, or D♭ as a minor ninth, I take the former much higher than the latter: thus it is not the slight variation from the temperament which here disturbs and hampers the violinist. The mathematical accuracy is not fitted for an intellectual performance, although it may be perfectly acknowledged; for, otherwise, how should I admit the sharpening of one note and the flattening of the other? The feeling of what is right and good is everywhere the ruling principle of our being, as we come from the Creator's hand, and what accords therewith, that is good" (ii. 191).

"We may assert that even the mathematically true intonation does not suffice for an animated performance; we wish the leading note to be higher, and a dominant and diminished seventh lower than the mathematical intonation requires. In the two passages, C, D♭, C, and C, C♯, D, it is certain that the D♭ will be sung flatter than the C♯, although the former mathematically is 15 : 16; the latter 24 : 25. This is the psychical view of intonation, that the clavier can know nothing of" (ii. 191).

men in devising what are called *systems of intonation*, in order, with the least possible complexity and trouble, to produce music on keyed instruments perfectly or approximately in tune.[1]

Now, in order to get over all this fearful complication, there has been adopted an ingenious process of *compromising*, which simplifies enormously the construction of the scale, particularly in its chromatic parts. It will be seen, in the first place, that the distance between E and F, and between B and C, is nearly half that between C and D or G and A; and also that C♯ and D♭, G♯ and A♭, &c., are not very different from each other. And, putting all these things together, it follows, that if the octave is divided into *twelve equal parts*, a set of notes will be produced not much differing from the true ones, and with the property of *being applicable to all keys alike*.

Hence has arisen the modern pianoforte clavier. The equal duodecimal division of the octave was familiar to the Greeks, but its modern introduction is usually ascribed to Adrien Willaert, a learned and clever Belgian composer, who lived about the middle of the sixteenth century. By this system the octave is divided into *twelve equal semitones*, each semitone being tuned alike to an interval = $\frac{1}{12}$ of an octave.

This system of tuning is called *equal temperament*, and the semitone it produces is called a *mean semitone*. The value of a mean semitone, expressed in the usual form of a ratio, will be—

$$\frac{\text{Vibration-number of C}\sharp\text{ or D}\flat}{\text{Vibration-number of C}} = \frac{\sqrt[12]{2}}{1}$$

or expressed in logarithms—

A mean semitone = ·25· (more accurately = .025086.)

The value of any interval containing n semitones, on

[1] See many publications by the late General Thompson; also "An Elementary Treatise on Musical Intervals and Temperament," by R. M. Bosanquet, 1876; and a very large amount of matter inserted by Mr. Ellis, in his translation of Helmholtz.

the equal temperament, will be $= 2^{\frac{n}{12}}$, or in logarithms $= 25 \times n$.

To compare a mean semitone with other forms of semitone—

		Logarithmic interval.
The true *chromatic* semitone, C to C♯ .	=	18
The true *diatonic* semitone, C to D♭ .	=	28
The Pythagorean hemitone was . .	=	23

In order, however, to give a general comparison of the equally-tempered scale with the real one, it has been drawn on the Plate parallel with the correct one. To do so is very easy, as we have only to divide the octave into twelve equal spaces. Each of these spaces is a mean semitone, and two of them make a *mean tone.* The vibration-numbers are added to each note.

By this comparison it becomes easy to judge of the nature and magnitude of the errors resulting from the compromise. The most important are—

Equal-tempered notes.			
C	. . .	right.	
B	Major 7th .	too sharp by $\frac{1}{8}$	of a Semitone.
B♭	Minor 7th .	„ flat by $\frac{1}{8}$	„
A	Major 6th .	„ sharp by $\frac{1}{6}$	„
A♭	Minor 6th .	„ flat by $\frac{1}{7}$	„
G	Fifth . .	„ flat by $\frac{1}{50}$	„
F	Fourth . .	„ sharp by $\frac{1}{50}$	„
E	Major 3d .	„ sharp by $\frac{1}{7}$	„
E♭	Minor 3d .	„ flat by $\frac{1}{6}$	„
D	Major 2d .	„ flat by $\frac{1}{25}$	„
C	. . .	right.	

These errors have given rise to a great deal of controversy and discussion. The thorough-going advocates of the equal-tempered system ridicule what they consider the fanciful distinctions of just intonation; they say the equal temperament is near enough the truth to satisfy all reasonable ears, and insist that it ought to be established as the only proper foundation of modern music.

On the other hand it is urged, theoretically, that it is contrary to all the principles of music to consider or treat the sharps and flats as the same notes ; and, practically, that the equal temperament does *not* satisfy the ear, but on the contrary gives effects that many musicians consider very disagreeable.

If we refer to the table we find the fifth and fourth of the equally-tempered scale very close indeed to the truth, and in regard to these no fault need be found. The most important errors are those of the *thirds,* which are considerably wrong; and it is undoubtedly the fact that the major third is an interval in regard to which, from its prominent place in the major triad (the chord of nature), the ear is peculiarly sensitive. On the pianoforte this is not of so much consequence; but in the organ and harmonium, where the tones are sustained, a moderately sensitive ear finds the equally-tempered major third very harsh and disagreeable.

There is a good deal to be said on both sides, and the truth lies between the extremes.

Sensible people can have little sympathy with the extreme theorists who delight in reviling and despising the duodecimal scale. All practical musicians must admit that it has been one of the happiest and most ingenious simplifications ever known in the history of music; that it has been the means of advancing the art to an incalculable extent; and that the modern enharmonic system, founded upon it, has become so thoroughly incorporated into modern music, that it is difficult to imagine how it could now be abandoned.

But, on the other hand, one must, if one is to exercise reason and common sense in musical matters, be equally at variance with that other extreme party who would force on us the equal temperament in cases where perfect intonation can be obtained just as easily, namely, as in stringed instruments, or pure vocal music. It is only in keyed instruments, having a limited number of fixed

tones, that the difficulties of imperfect intonation arise; with the voice and the violin tribe there are no such difficulties, and hence well-trained singers or good violin players would, when guided by their ears, naturally keep their harmonies in tune. To prevent them from doing this, and to try to make them conform to the imperfect scale of the equal temperament, is an offence against musical perception unworthy of a true musician.

Whatever may be said in favour of the utility of the equal duodecimal division of the scale, no one with any knowledge of harmony can fail to perceive that the too-sharp third is musically unnatural and untrue, and it ought never to be tolerated in sustained tones, if the natural and true effect can be got. It is the possibility of getting this which gives such an inexpressible charm to stringed and vocal harmony, when unaccompanied by the intractable keyed instruments; and, in the true interests of sweet music, this kind of perfection ought to be encouraged by every means in our power.

In keyed instruments it is no doubt difficult to get true intonation consistently with reasonable simplicity of construction. It has, however, been shown to be possible to make organs or harmoniums of limited size, which shall fulfil this condition; and even with larger instruments certain palliatives may be applied. In church organs, for example, a mode of temperament (said to have been introduced, or at least approved, by Handel) was formerly in use which put the most useful keys well in tune; but unfortunately, by the perverse fancy of players, it has within the last fifteen or twenty years become disused.[1]

Possibly something might be done to improve the in-

[1] The modern practice of tuning all organs to equal temperament has been a fearful detriment to their quality of tone. Under the old tuning an organ made harmonious and attractive music, which it was a pleasure to listen to, even though it might be interrupted by a "wolf" now and then. Now, the harsh thirds, applied to the whole instrument indiscriminately, give it a cacophonous and repulsive effect, which people are glad enough to run away from. (See Appendix, Note E.)

tonation of orchestral wind instruments, if conductors took any interest in the matter; but no doubt, in the great majority of cases, the equal temperament must be adhered to. It may be to a large extent a necessary evil, but no evil ought to be tolerated when it is unnecessary.[1]

Values of the Intervals in the Modern Scale.

We are now in a position to fix the accurate values of the various intervals ordinarily used in modern music, according to the true scales hereinbefore described. And we may divide them into two classes, viz., *diatonic intervals*, derived from the major diatonic scale, and secondly, *chromatic intervals*, where the aid of chromatic notes is necessary to their formation.

Diatonic Intervals.

The most important intervals of the scale, called the *consonant* intervals, have their values fixed acoustically as follows, as will be fully explained when we come to consider the principles of harmony in Chap. XVII.

The *perfect octave* $= \frac{2}{1}$.
The *perfect fifth* $= \frac{3}{2}$.
The *perfect fourth* $= \frac{4}{3}$.
The *major third* $= \frac{5}{4}$.
The *minor third* $= \frac{6}{5}$.
The *major sixth* $= \frac{5}{3}$.
The *minor sixth* $= \frac{8}{5}$.

[1] The following remarks in Hauptmann's letters may be quoted:—

"Do you know that Spohr asserts that singers ought to learn by a well-tempered clavier?—! —? —: —; I do not know what sign I ought to put here, the proper one has yet to be invented. And where is the tuner to learn tempering? must he refer to a tempered set of forks? And why should the singers temper? Answer. In order to sing music, which is altogether contrary to the nature of vocal music, for with good vocal music it is unnecessary. It is also not to be learnt, thanks to the strength and influence of our natural organisation. But it is said, without temperament, it is impossible to sing with accompaniment!—as if we hear

The values of the dissonant diatonic intervals must be determined by calculation from these.

The *diatonic semitone*, B to C, is equal to a fourth, less a major third $= \frac{4}{3} \div \frac{5}{4} = \frac{16}{15}$.

The *major tone*, C to D, is equal to a fifth less a fourth $= \frac{3}{2} \div \frac{4}{3} = \frac{9}{8}$.

The *minor tone*, D to E, is equal to a major third less a major tone $= \frac{5}{4} \div \frac{9}{8} = \frac{10}{9}$.

The *augmented fourth*, or tritone, F to B, is equal to a major tone, F to G, plus a major third G to B, *i.e.*, $\frac{9}{8} \times \frac{5}{4} = \frac{45}{32}$.

The *diminished fifth*, B to F, is the inversion of this $= \frac{64}{45}$.

The *minor seventh*, G to F, is an octave minus a major tone, $\frac{2}{1} \div \frac{9}{8}$, or which is the same thing, two perfect fourths, $\frac{4}{3} \times \frac{4}{3} = \frac{16}{9}$.

The *major seventh*, C to B, is an octave minus a diatonic semitone, $\frac{2}{1} \div \frac{16}{15}$, or which is the same thing, a fifth plus a major third, $\frac{3}{2} \times \frac{5}{4} = \frac{15}{8}$.

Chromatic Intervals.

These are more troublesome to calculate, as there is sometimes an uncertainty as to the whereabouts of the chromatic notes used in them.

The *chromatic semitone*, C to C♯. Here the C♯ may fairly be considered as the major third to the A below; in which case the interval is a major third less a minor third, or $\frac{5}{4} \div \frac{6}{5} = \frac{25}{24}$. Or suppose we take it downwards, say from A to A♭, the A♭ may fairly be considered as a major third below C, which gives us the same result as before.

The *diminished octave*, C♯ to C♮, is the inversion of this, $= \frac{48}{25}$.

The *augmented fifth*, C to G♯. Here, as the G♯ is

no false sounds except those that temperament leads to! (i. 192.) The singer will not temper (ii. 34.)

"When this lie of temperament once enters, it brings a thousand other lies after it. According to the 'cycle of fifths,' the most innocent *morceau* in C major, which never leaves the key, must be played with all the tempered notes" (ii. 114).

usually resolved upon A, it is reasonable to consider it as a major third above E, so that the whole interval consists of two major thirds superposed, or $\frac{5}{4} \times \frac{5}{4} = \frac{25}{16}$.

The *diminished fourth*, G♯ to C, is the inversion of this $= \frac{32}{25}$.

The *augmented sixth* may be represented, for the key of C, as extending from D♭ to B♮. Now, as there is usually a third note of the chord, F, we may most naturally assume the D♭ to be a major third below this, which makes the whole interval a major third plus a tritone, *i.e.*, $\frac{5}{4} \times \frac{45}{32} = \frac{225}{128}$. Or, taking the usual resolution of this interval on to the two C's, we may consider that the B has to rise and the D♭ to fall each a diatonic semitone; so that we get the whole interval as an octave minus two diatonic semitones, *i.e.*, $\frac{2}{1} \div \frac{16}{15} \div \frac{16}{15} = \frac{225}{128}$, as before.

The *diminished third*, B♮ to D♭, is the inversion of this, $= \frac{256}{225}$.

The *diminished seventh* is also an awkward interval to calculate. In the scale of A minor, it is represented by G♯ to F, and the G♯ is obviously the major third above E, or a minor third below B. So that the whole interval will be a minor third, G♯ to B, plus a diminished fifth, B to E, *i.e.*, $\frac{2}{5} \times \frac{64}{15} = \frac{128}{75}$.

The *augmented second*, F to G♯, is the inversion of this, or $\frac{75}{64}$; or we may calculate it independently as a major third, E to G♯, less a diatonic semitone, E to F, *i.e.*, $\frac{5}{4} \div \frac{16}{15} = \frac{75}{64}$, as before.

The above results are stated, together with their logarithmic equivalents, in the Table of Intervals, pages 77 and 78.

Values of Intervals in Equal Temperament.

The following table will be interesting, as showing a roughly approximate comparison between the true values of the intervals and those given by the equal-temperament tuning, as on the pianoforte. Some more accurate data will be found on page 150.

True Intervals.			Corresponding Intervals in Equal Temperament.		
	Ratio.	Log.		Ratio.	Log.
Chromatic Semitone	$\frac{25}{24}$	18	1 Semitone	$\frac{2}{1}^{\frac{1}{12}}$	25
Diatonic Semitone .	$\frac{16}{15}$	28			
Minor Tone . . .	$\frac{10}{9}$	46	2 Semitones	$\frac{2}{1}^{\frac{2}{12}}$	50
Major Tone . . .	$\frac{9}{8}$	51			
Diminished Third .	$\frac{256}{225}$	56			
Augmented Second .	$\frac{75}{64}$	69	3 Semitones	$\frac{2}{1}^{\frac{3}{12}}$	75
Minor Third . . .	$\frac{6}{5}$	79			
Major Third . . .	$\frac{5}{4}$	97	4 Semitones	$\frac{2}{1}^{\frac{4}{12}}$	100
Diminished Fourth .	$\frac{32}{25}$	107			
Perfect Fourth . .	$\frac{4}{3}$	125	5 Semitones	$\frac{2}{1}^{\frac{5}{12}}$	125
Augmented Fourth .	$\frac{45}{32}$	148	6 Semitones	$\frac{2}{1}^{\frac{6}{12}}$	151
Diminished Fifth .	$\frac{64}{45}$	153			
Perfect Fifth . . .	$\frac{3}{2}$	176	7 Semitones	$\frac{2}{1}^{\frac{7}{12}}$	176
Augmented Fifth .	$\frac{25}{16}$	194	8 Semitones	$\frac{2}{1}^{\frac{8}{12}}$	201
Minor Sixth . . .	$\frac{8}{5}$	204			
Major Sixth . . .	$\frac{5}{3}$	222	9 Semitones	$\frac{2}{1}^{\frac{9}{12}}$	226
Diminished Seventh	$\frac{128}{75}$	232			
Augmented Sixth .	$\frac{225}{128}$	245	10 Semitones	$\frac{2}{1}^{\frac{10}{12}}$	251
Minor Seventh .	$\frac{16}{9}$	250			
Major Seventh . .	$\frac{15}{8}$	273	11 Semitones	$\frac{2}{1}^{\frac{11}{12}}$	276
Diminished Octave .	$\frac{48}{25}$	283			
Perfect Octave . .	$\frac{2}{1}$	301	12 Semitones	$\frac{2}{1}$	301

The Minor Diatonic Scale.

In speaking of the diatonic scale in the last two chapters, it has been assumed to be the modern *major scale;* this

being the simplest one in construction, and the one most in use.

There is, theoretically, but little to say about the other modern variety, the *minor scale;* for the reason that the intervals of which it is made up are generally the same as those of the major scale, and are determined by the same theoretical principles. The difference is in the *tonality.*

It has been seen that after the idea of a *tonic,* or the existence of one peculiarly important note, became fully established and acted on as a fundamental element in music, the majority of the old modes were gradually abandoned. There was, however, a lingering wish to get some variety, if possible, and hence, in addition to the *Lydian* which is our modern major mode, the *Hypo-Dorian* was also retained, forming our modern minor mode.

The latter has the recommendation of corresponding with the two most important modes of the Church, the first and third, in regard to the nature of the note forming the third above the tonic. In the Church modes this interval was a *minor* third; and the partiality for this appears to have so far established itself in serious music, that the Hypo-Dorian mode was not only acceptable, but was for a long time in great favour for Church compositions, as is evidenced by the very large use of the minor mode by early composers.

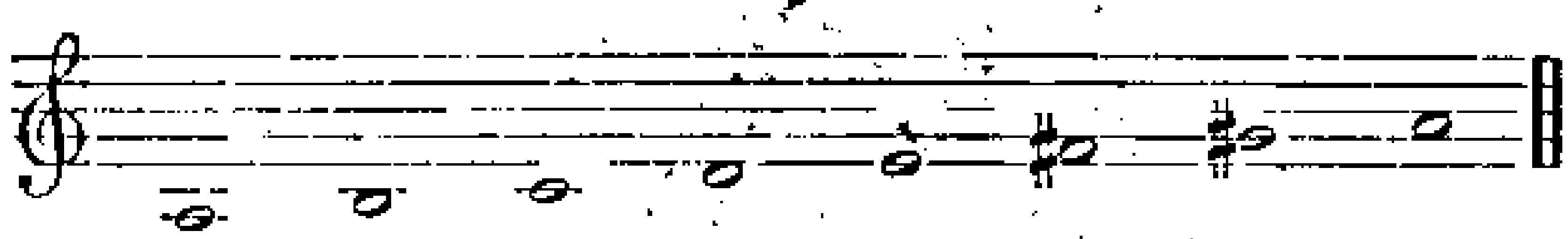
But the Hypo-Dorian mode involved some difficulty in the adaptation of harmony. The other one, the major, lent itself freely and easily to the harmonic combinations desired. Thus, in using what is called the "perfect cadence," customary at the close of a piece, where (in accordance with an acoustical principle hereafter to be explained) the final tonic harmony was preceded by that of the dominant, the major mode gave the cadence thus—

In applying this to the minor mode, the cadence would be thus—

But it appears to have been considered necessary, in modern tonality, that, for the purpose of defining the key in which a piece of music is written, the first chord of the perfect cadence should have a major third, and hence it is customary to alter the G to G♯ thus—

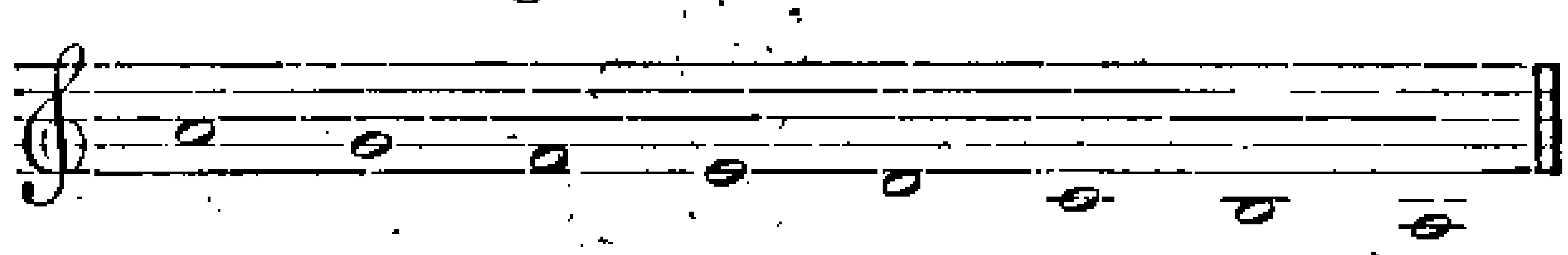
In accordance with this, the minor ascending scale becomes

But here there is another thing objected to, namely, the wide interval of an augmented second between the sixth and seventh notes, F♮ and G♯, which is said to be abrupt and unnatural, and this has led to the substitution of F♯ thus—



This is the most usual form of the ascending minor scale, and it will be seen that it is made to correspond with the major one in all its notes except the characteristic third. It will be remarked, however, that the scale here loses the diatonic form, as four whole tones come together, an arrangement unknown in any true diatonic scale.

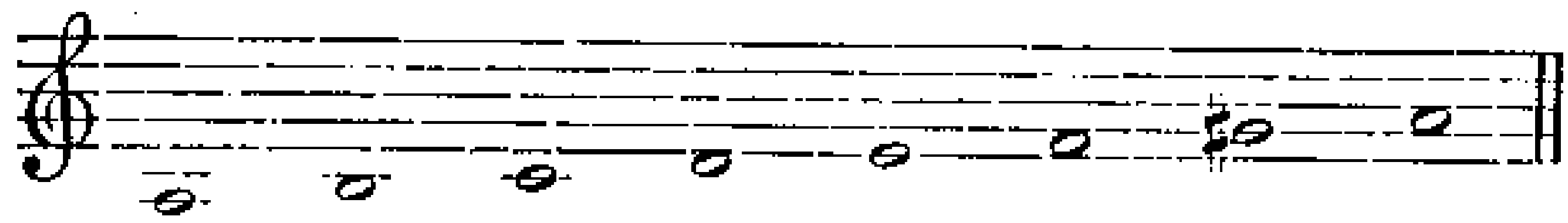
In the descending scale the normal form of the old



Greek mode is retained.

The change of the sixth note is not universal, for very

frequently the form is used both for ascending and descending, in spite of the augmented second—



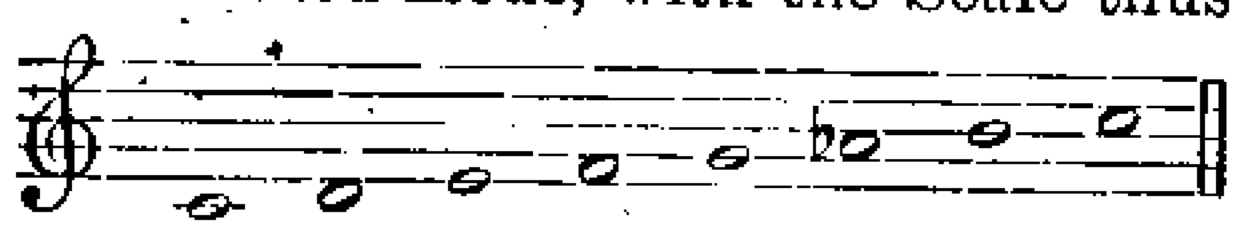
Now, it is curious that the upper part of this form of the scale corresponds with the *chromatic genus* of the ancient Greeks, in which the division of the tetrachord comprised two intervals of a semitone each, with one interval of a tone and a half (see page 95). Here again, therefore, the scale loses its diatonic character.

It is evident that the alterations above described destroy the individuality of the arrangement as it stood originally; and hence the minor mode, as used in modern music, can hardly be considered as an independent form.

The Minor-Major Mode.

There seems to be, however, some peculiar fascination about the Greek chromatic genus, as many modern composers have evinced a desire to apply it to major as well as to minor music; as, for example, in a final plagal cadence, thus—

Hauptmann (followed by Helmholtz) seems disposed to admit this as a third mode, with the Scale thus—



which he calls the *moll-dur Tonart*, or minor-major mode. It appears that this (according to Gevaert, page 293), is common in the chants of the Greek Church and in other Eastern nations. It is, of course, like the modern variable minor, no distinct mode in the original diatonic sense.

CHAPTER XIII.

TIME, RHYTHM, FORM.

THERE is a feature belonging to music which has not yet been described—that is, *its measured movement*, which we are in the habit of calling musical *time* or *rhythm*.

This is now generally looked upon as an essential feature of all modern compositions. There are, it is true, some few cases of music in which it is relaxed, as in church chants and in operatic recitatives; but these are exceptional, and it is matter of everyday knowledge that the division of music into equal portions, which are intended to be performed at a uniform rate of speed, is almost universal.

The introduction of the element of time into music, in some sort of way, is very old—possibly almost as old as music itself. It is evident that in all sustained sounds, such as those with the voice, there must be some *duration*, and the time of the duration of each sound must have had attention; for when several people sang together, this attention to time must have been an absolute necessity.

Then when music and poetry went together, the metrical division which we know existed in the latter must have been infused to some extent into the former. And when another amusement, dancing, was combined with music (as we know to have been the case in the earliest times), rhythmical features in the music must have been inevitable.

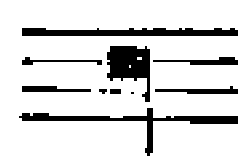
But from these embryo ideas to our present perfect and elaborate system of musical rhythm, is a very wide interval; and we find when we come to examine the records of ancient music, that although the idea of time is certainly present, the application of it is very rude.

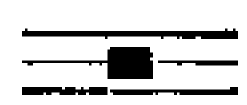
The Greeks had a most elaborate system of metre and rhythm, but it belonged chiefly to their poetry. The principal way in which they applied the idea of time to music was by making the duration of the sounds of unequal lengths, corresponding to the measures in their poetry, so that, in the singing, the long syllables should be sung to long notes, and the short syllables to shorter notes. This was natural; but there is evidence that the idea was carried farther, as signs for unequal length of notes existed in music unaccompanied by poetry, coming a little nearer to our modern independent time.

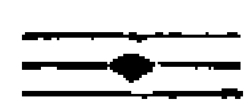
Whether, or to what extent, measure existed in the music of the early Christian Church is a matter of doubt. The silence of Guido d'Arezzo and others of his time (the eleventh century) about it has led to the general impression that the Gregorian music had originally no signs to distinguish time; but Fétis, in his "History of Music," has succeeded in showing the existence of measurable signs in Church music of the beginning of the seventh century, as established by St. Isidore at Seville.

When the writing of music first took the form which was the germ of the present notation, namely, about the tenth or eleventh century, the notes were given different shapes to signify different lengths of time during which they should be held.

There were three—

A Long . . . 

A Breve . . . 

A Semibreve . . 

These represented a sort of *proportionate* duration, the one to the other; the breve being intended to be held about half the time of the long, and the semibreve about half the time of the breve, as its name implied. This, however, was not the same thing as our present notion of musical time, inasmuch as there was no idea of any regular uniform *measure* running through the whole piece. The first idea of this appears to have sprung up soon after the notation was established; and, no doubt, it was the facility which this gave to the measurement that led to its invention. The first efforts were very imperfect, but in proportion as *counterpoint* became adopted, *i.e.*, as the various parts or voices took independent melodies, the plan came into use of setting notes of different values against each other,—two semibreves to one breve, two breves to one long, and so on,—and then, in order to perform these properly, the regular measure became a necessity, and so it has gradually improved till it has reached its present perfect state.

The most prominent application of the principle is the well-known division of the music into *bars* or *measures.* These are clearly analogous to the measures in poetry; and like them they are of several varieties, according to their modes of sub-division.

Thus, for example, we have the following kinds:—

	Main Divisions.	First Subdivisions in each Main Division.	Signs.
Binary or Common time.	2	2	¢ $\frac{2}{2}$ $\frac{2}{4}$
	4	2	C $\frac{4}{4}$
	2	3	$\frac{6}{4}$ $\frac{6}{8}$
Ternary or Triple time.	3	2	$\frac{3}{2}$ $\frac{3}{4}$ $\frac{3}{8}$
	3	3	$\frac{9}{4}$ $\frac{9}{8}$

These modifications give great variety in the style of

music, which is much further enhanced by modifications of the *rate* at which the measures are taken.

We have all sorts of gradations in this respect, which are expressed by the familiar Italian words :—*Grave, Lento, Largo, Adagio, Andante, Allegro, Allegretto, Vivace, Presto, Prestissimo,* and so on. It is true, as all Italian scholars know, that most of these terms have a wider signification than a mere representation of speed—they refer more to the style of movement, as for example—

Largo, . .	properly signifies		*roomy.*
Adagio, .	"	"	*easily.*
Andante, .	"	"	*"going," flowingly.*
Allegro, .	"	"	*joyfully.*

Still, however, they give an idea of velocity which is usually understood by the performer.

To render more certain the intention of the composer in regard to speed, it is very customary now to give what is called the indication by *metronome,—i.e., the actual number* of crotchets or minims or quavers per minute, which is measured by a little oscillating pendulum machine, invented for the purpose by a German named Maelzel.

There is another feature, borrowed from poetry, in the constitution of these measures, namely, *accent.* It is customary, as a normal practice, to emphasise the first note of each measure, so as to bring out clearly the effect of the mensural division; and this is also extended in some degree to the sub-divisions, particularly if the measures contain many notes, and are taken slowly.

In modern music, however, the principle of rhythmical division is carried farther than the simple bars: these form the first measuring elements of the composition; but there are larger divisions into what may be called phrases, sentences, or periods, usually of two, four, or eight bars each.

The most marked examples of rhythmical division are found in marches and dance music. In some kinds of

dances this is absolutely necessary to make the music fit the figures. But in waltzes and marches this is not so; there being no figures, and yet the rhythmical division seems absolutely necessary to please the ear, for waltzes or marches without rhythm would be considered unendurable.

In hymn tunes and in simple songs the rhythm of the tune is made to fit the prosodial construction of the words. In some kinds of learned and complicated music, such as fugues and canons, the rhythm is often obscure, and sometimes almost wanting; but these cases are exceptional, and are allowed on the principle that the attention of the mind is sufficiently occupied and satisfied by other features. But we may take it as a general principle that modern music is expected to be rhythmical; the mind feels a desire for the divisions, and undoubtedly they form a great element in the satisfaction gained.

Then it is worthy of remark that the sense of pleasure from the measured and rhythmical element in music is stimulated and heightened by occasional departures from it. This involves no paradox, for it is a well-known principle in the laws of human nature that occasional interruptions in a habit or uniform sensation only serve to mark its existence more strongly; and we shall find when we come to consider the subject of harmony, a very striking application of this principle in the use of discords.

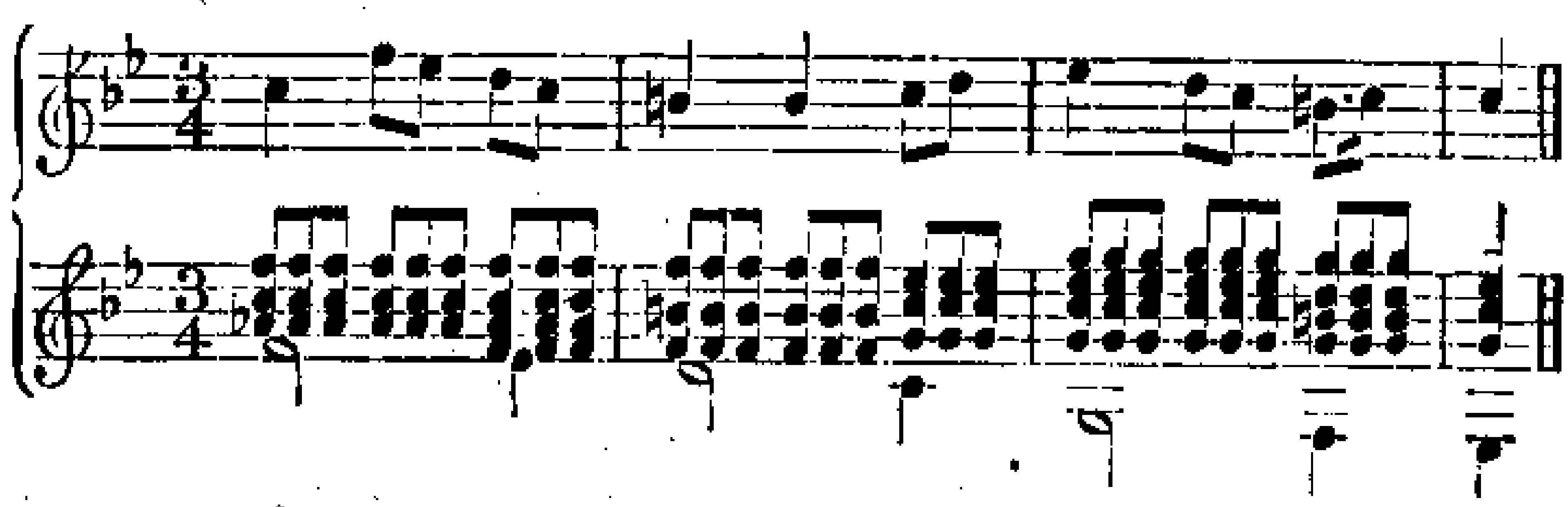
The interruptions here are of several kinds. In the first place, there is the alteration of *uniform* motion, by temporarily quickening or retarding the rate of performance; alterations which are expressed by the well-known Italian words *accellerando* or *rallentando*. Or the motion may for a short time be stopped altogether, as in the case of what is called a *pause*.

Then the interruptions are very frequent in regard to *accent*. Instead of the first note of the bar, some other note may be accented, and this may go on for several bars

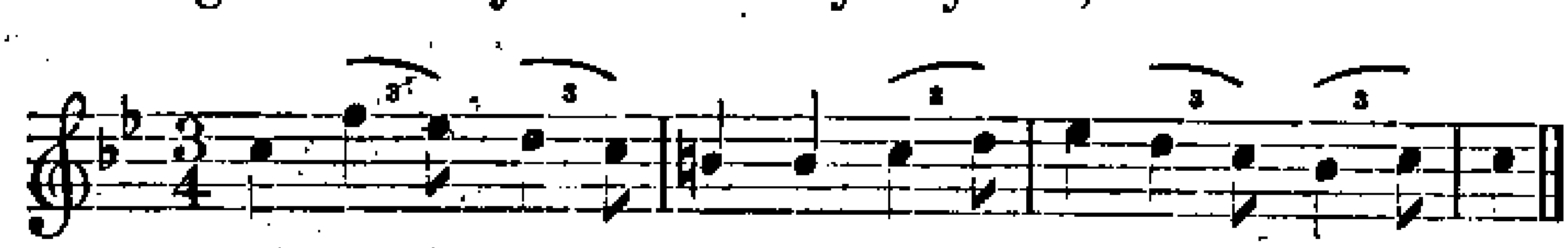
together in what is termed *syncopation*. And there may be great varieties of abnormal *emphasis* placed on particular portions of the music, in a manner analogous to emphasis in speaking.

In this respect music goes far beyond its rhythmical prototype poetry, for the departures from normal accent in poetry are infrequent, whereas in music they very often occur. Indeed the varieties of accent and emphasis constitute often the greatest charms in compositions of genius.

There is one curious arrangement of abnormal time which has been used much of late, namely, the contrast of binary and ternary division going on at the same time; thus—



This is not unknown in old composers, but it has been carried much farther by the moderns. Mendelssohn, Schumann, and Brahms have used it largely. One of Mendelssohn's *Lieder ohne Worte*, and a song from his Oratorio of "St. Paul" (from which the example is taken), are constructed so throughout. The effect is very good when the thing is properly done; but, unfortunately, it is very seldom properly done. It is difficult to do, and inferior performers will not take the trouble to learn how to do it; and hence it is most commonly smudged over by altering the binary into ternary rhythm, thus—



which, of course, destroys altogether the intention of the composer.

There is a still wider application of the element of regularity in what is called *musical form*. The habit has grown up of not only dividing music off into rhythmical periods, but of adopting certain more general features of systematic arrangement, in order to bring the ideas into a shape more easily appreciable by the mind.

One may fancy a musical composition which, though it may be divided into measures and groups of measures, consists of a constant succession of heterogeneous ideas, none of which have any relation to any others going before or after them. This may be called *amorphous* music, *i.e.*, music without form; and even though the ideas presented might be very good, it would be tiresome and wearying to listen to. The constant effort of the mind to take in and appreciate the incessant novelty would be so great as to destroy the pleasure.

All great composers have perceived this, and they have, therefore, taken care to lighten the effort by causing a composition to contain but few novel ideas, and giving the chief interest by their skilful and musician-like treatment. For example, in the old form of composition called *fugue*, the chief ideas were only one or two subjects of a few bars each, which were repeated over and over again, with novel and skilful combinations and modifications, which the mind could follow with pleasure, and without undue exertion. Although this form is much neglected, fortunately it is not obsolete, for a good fugue, by a clever modern composer, is as much appreciated now as ever. Mozart had the genius to write fugues which combined the ancient form with the modern style of music, of which the last movement of his "Jupiter" Symphony, and his overture to *Die Zauberflöte*, are remarkable and wonderful examples.

In more modern forms of composition, such as sonatas, symphonies, and so on, regularity of structure is carried out on the same principle, namely, by presenting few and strongly-marked novel ideas, and making the interest consist chiefly in their development and treatment; but

the principle is applied in a different manner. To illustrate this, however, would lead us too far into the details of music. Suffice it to say, that the study of *form* in music means the study of how this has been done by the best writers, and how students should try to imitate them.

There is a constant temptation with modern aspiring composers to throw off these trammels of form, and (especially if they are gifted with productive powers) to fill compositions with continuous successions of novel ideas, assuming that such a proceeding shows greater originality. But they forget that the regularity of structure has arisen, in the great writers, not from any paucity of ideas, but from a definite feeling of artistic necessity. Music is (so far as the public are concerned) not a duty of life, which has to be laboured at, but an enjoyment; and to be properly enjoyed it must be made easy of comprehension and apprehension,—and this, amorphous music of complicated structure cannot be.

But having said so much in explanation of what these elements of time, rhythm, and form are, we must revert to the principal object of our present investigation, which leads us to inquire what are the principles that have determined their use in music. It is clear they have nothing to do with acoustics; nor is it easy to conceive any physical principles that can enter into the explanation in any way; except so far, indirectly, as the physical phenomena of nature may, perhaps, influence the partiality of the mind for regularity of motion and symmetry of structure.

We must turn, therefore, to the other alternative, and we have no difficulty in perceiving that the principles which determine the introduction into music of systematic metrical division, and regularity of form, are purely *æsthetical*. Our minds and feelings are so constituted that, either by nature or by education, or by a combina-

tion of both, we take a certain pleasure in regularity of movement, and in the recurrence of systematic periods, in anything that is in motion. The feeling is independent of music; the eye takes pleasure in symmetrical forms and in symmetrical divisions, and the ear will appreciate rhythm perfectly well even though unaccompanied with musical sounds. The measured rappel of a drum is unmusical rhythm, and it was the rhythm of the hammers that suggested to Handel his air of the "Harmonious Blacksmith." The reasons given in chap. v. for the arrangement of musical sounds in steps or degrees are also perfectly applicable to regularity of division in time. The motion must be of such a character as to be *measurable* by immediate perception, and the uniform accented division by bars furnishes the measuring-rod by which the motion is estimated and appreciated by the mind.

Now it is easy to see that as some sort of rough measurement was at early times introduced into music, the writers, becoming gradually more appreciative of its capabilities, found that it was possible to carry the element of chronic regularity farther, and so to adorn the art with a powerful additional charm. In this way the features of time, rhythm, and form have, by constant improvements, attained their present elaborate musical development. And, what is more, they have, by experience and custom, become so firmly engrafted on the structure of modern musical composition, that we have come to consider them an essential part of its very existence.[1]

[1] See Appendix, Note B, p. 308.

PART THIRD.

THE STRUCTURE OF MUSIC.

CHAPTER XIV.

MELODY.

WE have now considered the more elementary arrangements of musical sounds: we have found that they are not taken at hazard, but that selections of them are used, arranged in definite respective positions, and called scales; we have learnt how these scales originated, what principles they depend on, and the different varieties of them that are utilisable for musical purposes.

We have further found the existence of an element called tonality, which influences in a large degree the use of these scales, and we have also noticed another feature, *i.e.*, measure or time, which is considered essential to the formation of modern music.

These data enable us now to go farther, and inquire on what principles the materials, so prepared, are built up to form the STRUCTURE OF MUSIC, according to the elaborate shape this structure has assumed in modern days.

It has already been said that music is made up of two things, melody and harmony; essentially distinct, but capable of effective combinations.

First, then, as to *melody*, which is a succession of single sounds; any tune or air, performed by one voice or solo instrument only, being called a melody.

We are so accustomed, in modern days, to hear and to think of melody as accompanied with *harmony*, that we hardly separate the two. But really, as Helmholtz remarks, melody is the essential basis of music; and finely-

developed music, in the shape of simple melody, existed for thousands of years, and still exists, in many civilised nations, without any harmony at all.

The melodies of any people must, of course, consist of notes taken from the peculiar scale they use. Attempts have often been made to write down the melodies of nations whose scale differs from our own, but these have seldom been satisfactory, from the difficulty of defining the sounds required, and from the abortive attempt to represent them by sounds of the European gamut, with which they do not coincide.

The earliest melodies we have any account of which do correspond with our scale are those of the Greeks, who, as has been already explained, used a diatonic scale essentially identical with that of modern music; and, fortunately, there are some examples obtainable of Greek melodies, though very few. Some manuscripts have been discovered where certain short poems or hymns have been marked, over the words, with signs for the musical notes to which these words were sung. There is a little uncertainty about the interpretation of some of these signs, and different commentators have, in consequence, given slight variations of some of the notes; but, on the whole, we are warranted in believing that we can reproduce the melodies with fair accuracy.

The best known is a hymn to Calliope, which, as quoted by Fétis,[1] is given below. The musical notation (which, of course, is modern) represents accurately the gradations of pitch of the notes, as indicated by the Greek signs; and the varying forms of the notes give an idea of the unequal duration of the sounds, some long and some short, which also formed part of the Greek system. The composition is declared to be in the Lydian transposing-scale (the one most commonly used), which, according to the table on page 117, corresponds with our key of F♯ minor, having

[1] Histoire de Musique, vol. iii., pages 215 to 220.

three sharps for the signature. Also some authors, judging by the final note, consider it to correspond with the Dorian octave-form.[1]

HYMN TO CALLIOPE.

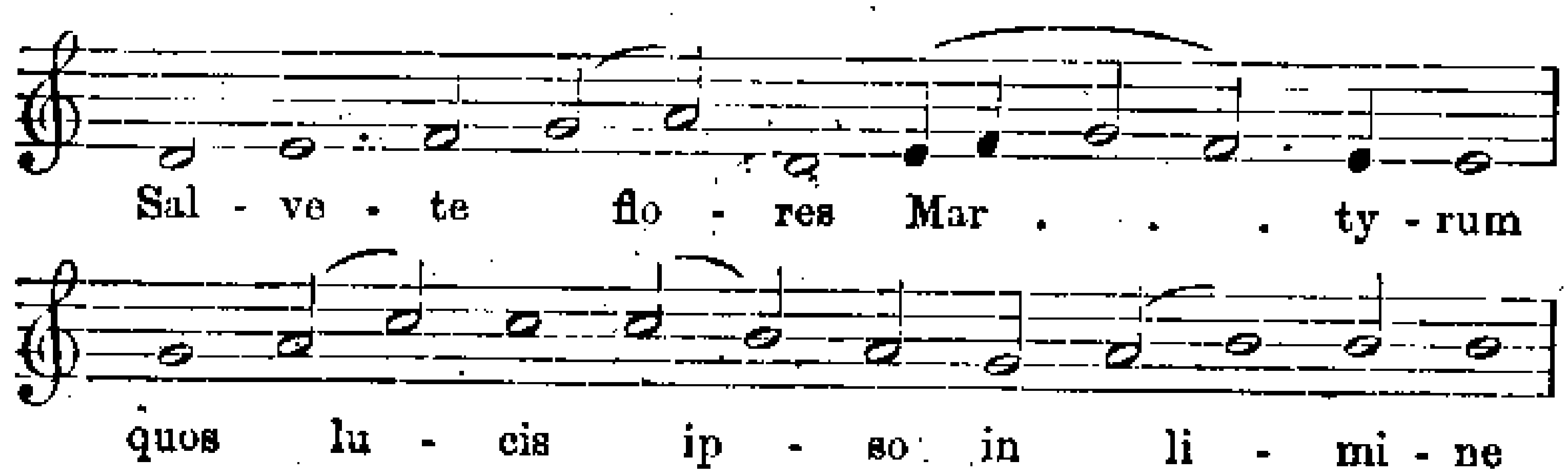
[1] According to Westphal, the actual pitch at which the hymn was sung would be some notes lower than here shown.

The melody sounds crude to our ears; for although the notes are taken from a scale corresponding to ours, yet there is no idea of *tonal relation* conveyed, no idea of its being in any particular *key*, and hence the effect to us is vague and unsatisfactory; also, although the notes vary in length, there is no general *systematic division* of time pervading the whole; nothing corresponding to our measure and rhythm.

Coming down some thousand years later, we find melodies in the music used in the Christian Church, and, fortunately for historical purposes, this music, owing to the more precise notation, has been better preserved.

We must not form our ideas of the early Church music from what is done under the name of Gregorian music in the churches of the present day. For, assuming that the succession of notes forming the melodies are preserved correct, they are given altogether a different and fictitious character by the addition of harmonies in the modern tonality. This anachronous transformation of the old things, must, to the earnest student of history, seem incongruous and of very doubtful taste; but if other people like it, and particularly if it pleases any one by ecclesiastical associations, there is nothing to be said. The only thing is to guard carefully against the impression that what is called Gregorian Church music now, conveys any true idea of what Gregorian Church music was like at its proper date.

M. Gevaert gives many examples of old Church melodies in the various Greek modes; the following is one in the Dorian:—



This sounds less crude to us than the Greek composition. It is more singable; the intervals are less wild, and it appears to have some tendency towards tonality, although there is no decided key. There are also long and short notes, but there is still no measured rhythm.

It is not within the province of this work to follow the gradual development of melody into its present form. Probably the earliest resemblances to modern melody would be found in secular compositions, such as the songs of the Troubadours. At any rate, when the two elements of tonality and of measured time and rhythm were systematically introduced as essential parts of music, it became necessary that melody should conform to them; and now-a-days a melody, in order to be admitted as such, must not only be in the proper notes of the scale, but it must convey a definite idea of its key, and it must be laid out in a definite measure, that can be easily detected and appreciated by the mind.

It may very pertinently be asked, how are melodies constructed? Assuming the general requisites of scale, tonality, and rhythm to be complied with, what dictates the choice of the notes? According to what rules must the notes be arranged? What is the difference in construction between beautiful and ugly—between pleasing and displeasing melodies? What are the standards of good and bad in their formation? These questions have often been asked and debated upon; but it has always

been found very difficult to give any satisfactory answer to them.

There have been certain *rules* established in regard to the class of melodies used for vocal music of early date; but these had merely to do with the facility for singing. They were to the effect that the intervals taken by skip must be such as the voice could easily hit on; that dissonances must move in the easiest way, *i.e.*, diatonically, and so on—all having to do with the facility of execution, and not with the effect on the hearer.

Helmholtz (p. 544, *et seq.*) treats of the scientific relations between consecutive notes in melody, but gives no explanation of their æsthetical character. Richter also (p. 163) gives illustrations of the modes in which melodies may be developed by musical skill; but takes no account of the invention of tunes. Sir George Airy, in his work on Sound, hazards an opinion that the same ratios of vibrations which, when combined, conduce to pleasing harmony, may, when existing between consecutive notes, be also pleasing in melody. This is, no doubt, true, but the explanation does not go far enough, inasmuch as there are abundance of pleasing melodies which no such explanation will account for. In fact, no one has made any successful attempt to analyse what are the particular features that constitute pleasing melody, or to explain why we like some melodies in preference to others; why some are popular and attractive, while others are passed over with indifference.

It would appear that the problem which has puzzled so many thinkers is of the same nature as many other obscure points of æsthetical philosophy. It is difficult in many branches of art to define what are the exact features of composition which cause the pleasure we receive; we estimate the power of pleasing by some æsthetic power of appreciation, and we must be content, at present, to leave the explanation open. The question forms a branch of the greater problem mentioned on pages 15 and 16, namely,

the aesthetic analysis of musical works with reference to their effect on the mind; and there is no branch more subtle than the appreciation of melody.

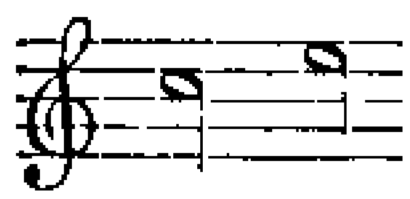
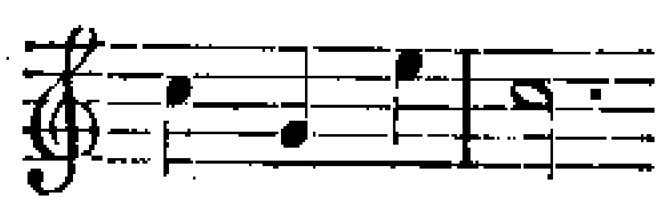
At any rate, for our present object, we may be pretty certain that the structure of melody does not follow any rules which can be referred to a *physical* origin; it is entirely determined by the will of the composer, who, only provided that he conform to the established elementary arrangements of his material, may give his fancy, taste, and imagination liberty to soar unfettered, as high and as freely as the wings of his genius will carry him.

CHAPTER XV.

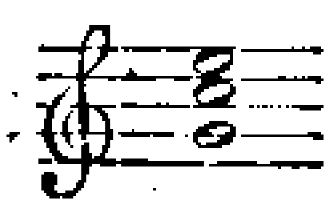
HARMONY.

A.—History.

We must now take in hand the other branch of musical composition, namely, *Harmony*. This is, as has already been said, the effect produced when two or more sounds differing in pitch are heard *simultaneously;* in contradistinction to *melody*, where they are heard *successively*. The distinction may be shown by such passages as these—

 or 

which constitute melody. But when the same notes are put into these forms—

 or 

they constitute *harmony*.

Hauptmann has drawn an elegant and philosophical distinction between melody and harmony. He says melody conveys essentially the idea of *motion;* harmony is consistent with the idea of *rest*. Melody must go on, or it is not melody. In harmony the musical idea is complete, even though it stand still. A *chord* of sustained notes gives a perfect and complete idea to the mind. It is true, we have *progressions* in harmony (and very important they are), but they are in reality successions of separate ideas, each more or less complete in itself; whereas in melody the succession only forms one idea as a whole.

In modern music harmony plays a very important part,

on account of the great variety and elaboration it is capable of, and the attention always paid to it by the best composers. It has, moreover, formed the subject of innumerable theoretical studies and treatises; indeed, so far as the theory of music is cultivated in the ordinary course of education, it is directed much more to harmony than to any other branch of the art. It is clear, therefore, that in investigating the principles of music we must naturally give much attention to harmony.

Before, however, we go into this, it will be instructive to inquire a little into the *history of harmony*, in order to form an idea how it has grown up into its present state.

It seems to us, in the present day, a very simple thing, having given a musical scale, to sound several notes of it simultaneously. But, simple as this idea seems now, it has only been carried out in comparatively modern times. All the most ancient music we know is simply *melodial*, and wherever any clear descriptions of systems of music differing from our own have been obtained, the melodial succession of sounds appears to have been the only form of music considered practicable.

We have traced our system back to the Greeks, and, of course, it is a natural inquiry whether they, having a scale like ours, were ever in the habit of using its sounds *simultaneously* in the manner which we now understand by the term harmony. Unluckily, however, this question is one of the most obscure and most controverted connected with their musical system. We have positive and tolerably clear information about the melody of the Greeks; but in regard to harmony the case is quite different, for not only is there no specimen of such a thing on record, but there is no passage to be found in any Greek author pointing, in a positive and unequivocal way, to the use of simultaneous sounds. The disputes have all turned on passages of doubtful signification, which have been interpreted by different critics in different ways.

The word Ἁρμονία is in frequent use among Greek writers on music, but although it has become incorporated into modern language as having reference to simultaneous sounds, this was not its original meaning. In chap. ix. it has been quoted as relating to the succession of sounds within the octave; but it had at other times a much more general significance, and Mr. Chappell thinks it was nearly synonymous with our word "music," the Greek word *Μουσική* comprising still more, and including poetry. It is not, therefore, in regard to the word *harmonia* that the question has arisen; the disputes have turned on the exact meaning that ought to be attached to another word, *Συμφονία*, which was also often used, and which, from its etymology, would certainly seem to convey the idea of simultaneous musical performance in some way or other.

Fétis, in a long dissertation laid before the Academy of Sciences of Brussels some years ago (and the substance of which is repeated in the third volume of his Histoire Générale de Musique), argues out ably and elaborately the whole question, and arrives at the following conclusion:—

As regards the Greeks in their best days, before the loss of their independence, it is certain that they made use of simultaneous singing in two ways, namely, in unison (*homophony*), and in octaves (*antiphony*); that *symphony* meant simply a continuous chant sung in octaves, or by the union of the voices of men with those of women or children, and that this word never had any more extended signification; moreover, that the instruments, when used with the voices, did nothing beyond accompanying them in the unison or the octave, which is not harmony in our sense of the word.

This opinion, however, has been dissented from by other authorities, among whom is M. Westphal. He agrees (and this, indeed, appears to be pretty generally admitted) that the purely vocal music was probably confined to unisons and octaves; but he believes that other combinations were introduced in instrumental accompaniments,

which at any rate would give the harmony a subordinate character.

Whatever the practice may have been, we may be certain that the Greeks were not wanting in knowledge of harmonic relations. We have already seen that they acknowledged the octave, fifth, and fourth as consonances; and the expression applied to them, κρᾶσις, "a mixing of two things so that they are blended and form a compound," shows that the effect of their combinations must have been perfectly familiar. We know also that, in the later times, the Greeks became aware of the harmonious nature of the true major third; and hence it is clear that they had, at least, all the knowledge necessary for the production of the major triad, the chief element of harmony. But we know further how thoroughly they studied the relations generally of their notes to each other; and from all these facts, it is scarcely possible to doubt that they were well aware of the effects that would be produced by simultaneous sounds. Helmholtz, however, suggests, and probably with reason, that although they knew of these harmonic combinations they did not like them, and, consequently, did not practise them, or allow them to form part of their musical system. And undoubtedly the broad fact, that among all their voluminous and detailed writings on music there is no positive and unequivocal mention of the subject, gives powerful support to this view.

After the Greeks had become subject to the Romans some evidences appeared, pointing in a more positive way to the use of simultaneous sounds. One of these is found just before the Christian era, in an ode of Horace, "Ad Mæcenatem" (lib. v., carmen ix.):—

> Quando repostum Cæcubum ad festas dapes,
>   Victore lætus Cæsare,
> Tecum sub alta (sic Jovi gratum) domo,
>   Beate Mæcenas, bibam,
> Sonante mistum tibiis carmen lyra,
>   Hac Dorium, illis Barbarum ?

This passage, which has also been the subject of much controversy, declares that at a certain expected festal entertainment a song would be performed in which the lyre, playing in the *Dorian* mode, would be accompanied by flutes playing in some other mode known as the *Barbarian*.

The dispute turns on what this barbarian mode was, and among other hypotheses the suggestion has been offered that it was one either a fifth or a fourth above the Dorian. So that, supposing a certain melody to be played by the lyre, an accompaniment of flutes would be added, consisting of the same melody taken either a fourth or a fifth higher.

Now, if this stood alone, we might conceive the explanation somewhat fanciful. But, singularly enough, it is confirmed by other evidence of about the same date, and it fits in very consistently with facts more positively known in the subsequent history.

A writer named Censorius, who lived at Rome about the middle of the third century, mentions the term "symphony," and gives a definition of it which, beyond doubt, includes the sort of harmony above referred to. He says: "In music there are only certain intervals which can produce symphony, which is a *simultaneous combination* of two different sounds. The first or simple symphonies are three in number, one having an interval of two tones and a semitone, and called *diatesserōn* (fourth); another of three tones and a semitone, called *diapente* (or fifth); and the third, *diapasōn* (octave), which contains the two former."[1]

We are next able to trace the same sort of thing down into nearer connexion with our own time, namely, into the music of the Church in the Middle Ages.

Isidore, Bishop of Seville, a contemporary and friend of Gregory, about A.D. 600, speaks of *combinations of simultaneous sounds*, and enumerates the *octave*, the *fifth*, and the

[1] Orig. in Fétis, vol. iii. p. 535.

fourth, together with their replicates in higher octaves, as consonant intervals which may be thus employed.

A chronicle of the beginning of the ninth century states that, under Charlemagne, French singers were taught by Roman ones to accompany a chief melody with a subordinate one, which was termed *organising,* and a little later we get a positive description of what this meant.

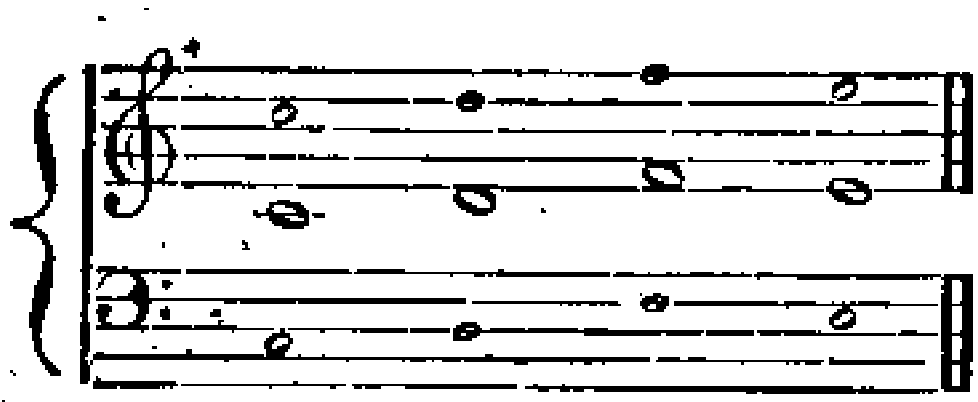
In the tenth century lived a Flemish monk named Hucbald, who showed that a melody could be accompanied in several ways, which were called Diaphony or Organising. The accompaniment could be formed by taking the same melody either—

in octaves above or below,
or in fifths above,
or in fourths above,
or in fifths above and fourths below,
or in fourths above and fifths below.

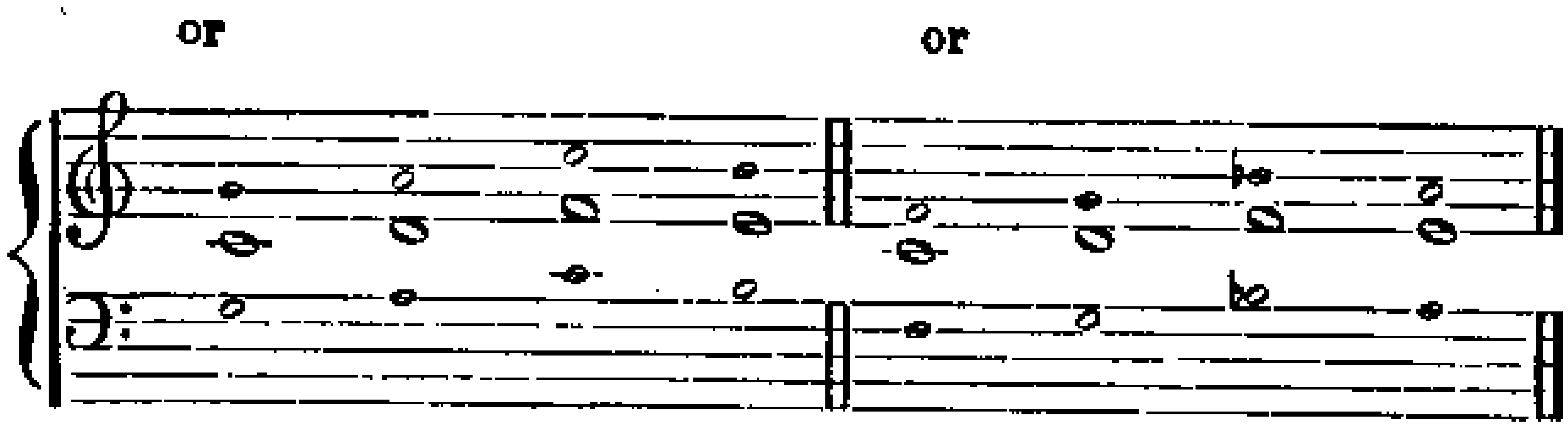
Here, therefore, is accumulative proof that during the first thousand years, or thereabouts, of our era, there was practised not only singing in unisons and octaves (which had existed long before), but also a kind of rude harmony, consisting of a duplication of the chief melody in perfect fifths and fourths above or below.

The following simple examples will illustrate the nature of these arrangements; the large notes represent a given chief melody; the small notes the accompaniments added.

The Greeks and other ancient nations accompanied thus, in octaves—



The later modes of organising, or diaphony, according to Hucbald, would be thus—



It need hardly be said that this kind of harmony would not be liked now, and much has been written about the so-called barbarity of these combinations. But we must recollect how very difficult it is for us, educated as we are, to put ourselves in the place of the people of that time, and to judge with the limited means of judging open to them. Helmholtz very pertinently says (p. 361):—"The feeling for historical artistic conception has certainly made little progress as yet among our musicians, even among those who are at the same time musical historians. They judge old music by the rules of modern harmony, and are inclined to consider every deviation from it as mere unskilfulness in the old composer, or even as barbarous want of taste."

Let us consider what, in the infancy of harmony, it would be natural to do.

The accompaniment of a melody in its octave had been practised from time immemorial. And when it occurred to people to accompany in any other interval, what so reasonable as to use the other concords standing next in order of perfection? The fifth and the fourth had been known and defined as concords ever since the time of Pythagoras; and why should not the attempt have been made to use these intervals for harmony?

There is nothing physically repugnant in successions of fifths. If a melody is either sung or played on any instrument with a brilliant tone, the octave and twelfth are very

prominent in the accompanying harmonics or overtones, and it follows that an accompaniment of consecutive fifths is an order of nature, and cannot, therefore, be condemned by natural laws. Consecutive *fourths* are still less unlawful; they are admitted in modern music without scruple.

Hence the objection urged to this mediæval diaphony, namely, that it sounds offensive to modern educated musicians, proves nothing as to its effect on persons to whom the present ideas were entirely unknown. And we may infer that it was not considered disagreeable, from the fact that the writers of the time described it as *suavem concentum*, or *honestissima suavitas*.[1]

We have traced the existence of this rude part-music back for a long period; but we have no information as to when or how the idea of simultaneous harmony first came into being. If the Greeks, with all their elaborate musical system and highly-cultivated artistic taste, did not know it, or, at any rate, did not think fit to use it, we may be pretty certain that their successors, the more effeminate Romans (who in musical matters merely copied them), did not add it, and it must have come from some extraneous source.

Fétis offers a plausible conjecture that the invention of harmony came from the tribes of Central and Northern Europe; was, in fact, of Teutonic origin. It is very probable, nay, well-nigh certain, that harmony was used and cultivated by the nations of the North at a very remote period, perhaps as early as the commencement of the Christian era, although no attempts were made for several centuries to engraft this secular harmony upon the melodies of the church.[2] And it certainly seems very appropriate that the nations of Germany, who have always most excelled, and

[1] See Coussemaker, Histoire de l'Harmonie au Moyen Age.

[2] See "Transactions of the Musical Association," 1875-76, paper by Sir Frederick Ouseley, p. 33.

still most excel, in this branch of music, should prove to be the descendants of those to whom its invention was originally due.

Soon after the time of Hucbald harmony began to take a further development; indeed, he himself gave some rules, though very imperfect, for another kind of diaphony involving occasional contrary motions, which would allow dissonant intervals to be heard together. Guido d' Arezzo in the eleventh century alluded to the two kinds of diaphony, and mentioned the use of the *major and minor thirds* and the *major second,* which would appear to show a considerable advance towards our modern ideas.

The added part accompanying the melody was at a later period termed Descant (Discantus), and we find that, in the twelfth century, it had so far emancipated itself from the simple form of the diaphony as to have rules made for its guidance as an independent part.

At this time, therefore, *counterpoint* may be said to have taken its rise, involving the writing of accompanying parts of independent structure, and not mere replicates of the principal *canto fermo.* When one such independent part had been contrived, it was naturally a step onward to add more. Accordingly, as early as the twelfth century, we find examples of *three-part* compositions; and a little later, namely, about the middle of the thirteenth century, these had been brought to a considerable degree of perfection.

But as the parts increased in number, it became necessary to pay more attention to the harmonies which the multiplicity of notes brought about, and accordingly we find, about the same time, Franco of Cologne writing elaborate rules on this point, and distinguishing carefully between the different consonant and dissonant harmonies that might be employed.

He was followed in the fourteenth century by another eminent musical theorist, John de Muris, who wrote on the same subjects, and by whom the word counterpoint (*contra punctum*) was first used. A mass in four parts was performed in 1360, at the coronation of Charles V. of France; and a little later we find, in some Church music by Dufay, that counterpoint had so far advanced as to show the introduction of what has ever since been one of its most salient features, namely, *Canon*.

From this time a gradual advance in style went on, as evidenced by the works of the great Belgian writer at the end of the fifteenth century, Josquin de Près, and of the still greater Roman musician in the middle of the sixteenth, PALESTRINA.

During all this time, although music in parts necessarily involved the harmony of simultaneous sounds, yet this harmony was not, for its own sake, the principal thing aimed at. The object of composers was strictly contrapuntal, *i.e.*, to write *independent parts*, the chief merit of which should be their individual character, and yet which, when sung together, would be so far harmonious as to be tolerable to the ear. The parts were frequently in concord, otherwise the ear could not have tolerated them, but they frequently also launched out into dissonant combinations; and it was found that these could be tolerated also, provided that they were subjected to certain conditions as to their motion and sequence.

Hence, *i.e.*, from the necessities of contrapuntal composition, arose the large use of *dissonances* in harmony, which, even when the immediate cause of them had passed away, retained their interest on account of the variety they gave to music, and the scope they offered to the ingenuity of composers.

These dissonances were much increased in number and importance by the more general introduction of chromatic notes, in addition to the old diatonic scale. When Ad-

rian Willaerts completed the chromatic scale of twelve notes to the octave, advantage was taken of it by his scholars and successors, Nicolo Vicentino, Cyprian de Rose, and the more celebrated Orlando di Lasso, who all produced many-part madrigals and other compositions in which new harmonies were used, founded on the added notes of the chromatic scale. It was even attempted to go farther, and, in imitation of the Greeks, to introduce enharmonic divisions. In one of the madrigals of Luca Marenzio, the notes F♯ and G♭, G♯ and A♭, D♯ and E♭, are prominently contrasted.

It was part of the work of the great Palestrina to check this sort of license, and, indeed, to restrict the use of chromatics generally so far as Church music was concerned; and by his good example a salutary feeling became established, that the simple diatonic genus was the most appropriate for the service of the sanctuary.

In spite, however, of all that Palestrina could do, the spirit of progress in regard to harmonical combinations, having been once aroused, was too powerful to be suppressed, and it found vent in the secular branch of the art, which at that time began to be cultivated, in the operatic form, by Monteverde and his associates, at the instance of the Italian party of the Renaissance. They had heard of the marvellous effects that had been produced by the music of the Greeks, and longed to imitate them; and their idea was, that one of the means by which they could do this was by multiplying and intensifying the dissonances in harmony.

We do not learn that the music so constructed rivalled that of Orpheus, which

> "Made trees
> And the mountain-tops that freeze,
> Bow themselves as he did sing."

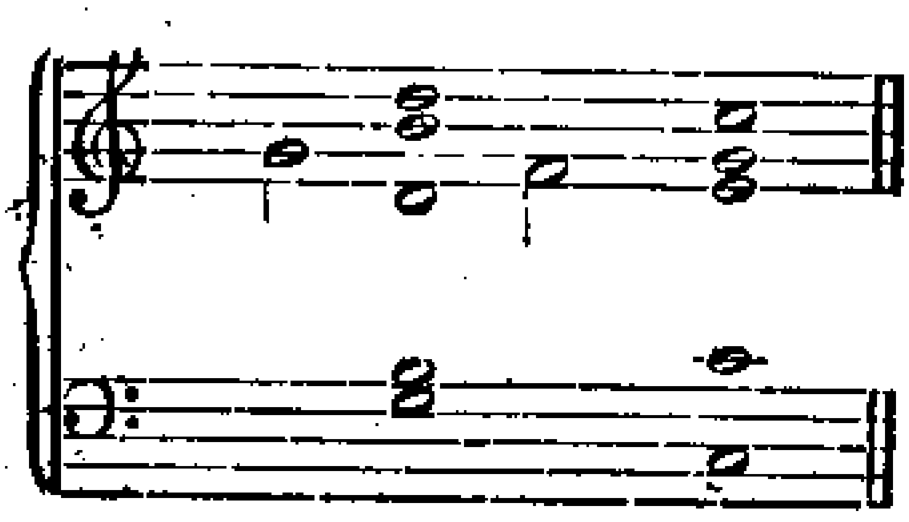
And the examples that are on record of the Renaissance combinations, do not convey to our ears a very favourable

impression. But still these efforts had an influence on the progress of harmony, and to Monteverde, in particular, is usually ascribed the credit of the introduction of one dissonant chord which is of the greatest importance in modern music, namely, that called the *dominant seventh.* It is (as will be shown hereafter) the peculiar property of this chord to define and determine the modern *tonality* of a piece, *i.e.*, to fix in the mind the idea of its being in a definite *key*. Monteverde was not the inventor of this chord, it had appeared clearly in earlier writers;[1] but he drew more attention to it, and after his time it may have been considered to have been adopted in music, and with it the definite idea of modern tonality, and the permanent adoption of the Lydian mode.

This was a great help to the study and practice of harmony, as henceforward the chords used in any piece could be linked together by laws and rules reducible to easy comprehension and equally easy application.

But, in addition to this great change, other advances of great import to harmony arose out of the efforts of the musical composers about the Renaissance time. The more precise definition of the key a piece was in, facilitated the production of variety by *departures* from that key, either by systematic modulation or by accidental discords. For this the duodecimal division of the scale gave great facilities. The modulation into allied keys, which had in

[1] As, for example, in the following passage from Palestrina's *Missa Papæ Marcelli*, on the words "Et homo factus est":—



reality been practised to a limited extent long before, was systematised and made much more easy by the use of accidental flats and sharps; and by the less regular use of chromatic notes many new discords were introduced, which have been of great use and powerful effect in modern harmony. The most important of these was the now well-known chord of the *diminished seventh*, which appears, probably for the first time, in a chorus for female voices in an opera by Monteverde, "Il Ballo delle Ingrate," produced at Mantua in 1608, the passage being as follows:—

The effect of this when new must have been very startling; it was eagerly laid hold of by musicians, and has been since worked to death, being the mainstay of inexperienced composers who aspire to fine writing.

The *augmented fifth*, another discord of much power, was also a consequence of the new chromatic system, and is said to have been first used by Luca Marenzio in 1593.[1]

As the practice of harmony advanced, we naturally find a corresponding advance in the mode of its theoretical treatment by writers on music.

The first author who treated of harmony, after it had become to a certain extent established in the contrapuntal music of the fourteenth, fifteenth, and sixteenth centuries, was Giuseppe Zarlino (Le Istituzioni Harmoniche, 1558). He gave fair and intelligible rules for the use of the consonances and dissonances (so far as they were then known), and his work formed the basis of most succeeding writings till the early part of the eighteenth century. Bononcini,

[1] Many of these historical particulars are taken from a valuable little brochure, "Geschichte des Septimen-akkordes," von C. F. Heitzmann. Berlin, 1854.

Handel's rival, wrote, in 1688, an improved work on the subject; and a still better and fuller one, "Das neu eröffnete Orchestre," by T. Mattheson, appeared in 1713, the great feature of which was bringing into strong light the importance of the harmony which he called the *Trias Harmonica,* and which we now know as the Triad or Common Chord.

All this time, however, although considerable attention was paid to harmony, yet it was only treated as *subsidiary to counterpoint.* All important compositions were written in distinct and separate parts or voices, and it was only by their *combination* that the effects of harmony were obtained.

The idea of *harmony independent of counterpoint, i.e.,* of *progressions of chords* without any particular movement of parts, had not then come into vogue, although it is an idea so familiar to us now that we can hardly picture to our imagination a state of music in which it did not appear. It appears to have taken its rise about the end of the sixteenth or the beginning of the seventeenth century; and probably the earliest practical realisation of it was the attempt of organists, in the Church service, to accompany a melody with harmony, and thus to fill up, in the absence of other voices, something that would imitate their contrapuntal effect. To guide them in this, they wrote out the melody as a bass (for in the old Church music this was the general position of the melody) and put *figures* over the bass notes, to indicate the other notes they should use for accompanying it, these figures representing the *intervals* at which such accompanying notes should stand, reckoning from the bass note upwards.

This was the origin of what we now call *Thorough Bass* (Bassus Generalis, Basso Continuo). The art was so useful that it soon became a special study, and rules, independent of the usual contrapuntal ones, were prescribed and published for its application.

Thus harmony, instead of being, as formerly, a subsidiary effect arising out of vocal part-writing, became what it is now,—a most prominent independent feature of music, to which counterpoint, when used at all, is merely ancillary.

Dr. Hullah, in his Lectures on Musical History, has happily contrasted the ancient contrapuntal and the modern harmonical music, by describing the former as *horizontal*, and the latter as *vertical* or perpendicular. In the former the composers wrote the several parts in horizontal layers, as a builder lays horizontal courses of stones; in the latter, they piled up notes one on the top of the other, as in building a series of columns.

It is impossible to give better illustrations of this distinction than from the works of Handel. This great man, the giant of choral music, lived just at the time when harmony had assumed an independent existence, but before the importance of counterpoint had passed away: his wonderful genius consequently seized both styles, and made the very utmost of each. And one hardly knows whether to admire most his sublime masses of harmony, or his wonderfully varied, skilful, and melodious contrapuntal compositions.

The first theoretical writer who, adopting the principle of independent harmony, reduced it to a connected and logical system, was Jean Philippe Rameau, a Frenchman, who was not only a clever musician and composer, but an accomplished scholar, a practised writer, and a learned man of science. In 1722 he published his celebrated "Traité de l'Harmonie reduite à ses Principes Naturels." It was afterwards republished by the eminent philosopher D'Alembert, and it has formed the basis of all theoretical treatment since that date. We shall have to speak more of this system hereafter.

Another point to be noticed in the progress of harmony

during the last three centuries, has been the change in the views regarding discords. Dissonant notes often resulted from the necessary movements of the various contrapuntal parts, but they were only tolerated as melodial progressions, and considered exceptional. But when harmony began to assume independence, these dissonant combinations, or *discords,* as they were termed, assumed a more legitimate form, and were introduced as substantive chords, giving thereby great force and energy to the composition, although (as we shall see when we come to speak more particularly of them) some of the rules and restrictions as to their application were still, to a certain extent, recognised and retained.

These discords being once admitted have been constantly in a state of development and increase, new combinations being frequently added of a nature which, in older time, would have been considered harsh and inadmissible; and so harmony has advanced to the complex state in which we know it now.

CHAPTER XVI.

HARMONY CONTINUED.

B.—Theoretical Rules and Systems.

IN passing on to consider the structure of modern harmony, it is necessary to bear in mind that our object here is limited. It would be foreign to this object to go, at any length, into the practical details of harmony: the problem before us is entirely theoretical, namely, to try to discover how far modern harmony is founded on natural, physical, or physiological phenomena, or how far it is due to those principles we have defined as æsthetical or artistic.

And in this we do not get much help from any of the ordinary treatises on the subject. These are not wanting in number, for their name is legion; nor in variety, for the views expressed in them are often wide as the poles asunder; nor in ability, for their authors are often men of great musical eminence; nor in practical value, for their usefulness has been beyond all question in promoting the knowledge of the musical art. But, for all this, they do little towards solving the question here proposed; indeed, they often throw difficulties in the way of its solution.

In speaking of treatises and instruction books on harmony, we must carefully distinguish between two very different kinds of matter they may and usually do contain, namely, *practical* and *theoretical.*

Practical instruction in harmony has an object perfectly

definite and intelligible. Its aim is to teach musical composition; *i.e.*, to enable pupils or students to write music in accordance with what is called the *grammar* of the art. With this view, teachers who devote themselves to such instruction lay down certain *rules*, as to what should or should not be done; and, generally speaking, these rules are formed by the study and observation of the practice of the best composers. The object is to direct the attention of the students to these examples, and to induce them to write in similar forms; which is clearly and undeniably the best thing for them to do.

Such practical instruction teaches the grammar of music on precisely the same principle as that which teaches the grammar of literature. Grammarians point out the forms which have been, and are, used by the best writers; they reduce them to a system, and hold them up for students to imitate. So with the grammar of music, the examples of the great composers are brought into systematic forms, and the pupils are taught to consider these forms as the standards of propriety.

But, in addition to practical instruction, we often come in contact with matter of a more theoretical character, involving what are called *Theories*, or *Systems*, of harmony.

There is some ambiguity as to what a *system of harmony* may mean. In one sense it may imply only the *classification* of the forms used in the best musical writings, which is legitimate and laudable, and highly useful for the purposes of instruction. It is, in fact, analogous to the many excellent systems of classification we have in the natural sciences, as in botany, mineralogy, conchology, zoology, and so on; or, still more appositely, analogous to the systematic arrangements of the parts of speech and the rules of syntax in grammar.

But many writers are not content with this. They mean by a "system of harmony" some theoretical mode of explaining, or accounting for, or deriving, the chords and

progressions which they find in use. When they see a fine passage used by a great composer, they are not content with taking it as it stands, and admiring it, as one would admire a beautiful group by Raphael, or a choice extract from Shakespeare; they think it incumbent upon them to *justify* the composer's use of it by attempting to show that it may be derived or accounted for on some ingenious *system* or *theory* which, in their opinion, may be pronounced legitimate and proper.

The first person who attempted this sort of thing was Rameau, in 1722. Before him, the publications on the subject were entirely practical; they had consisted only of rules and directions how to put music together, without any reference to the principles on which such rules were founded. Rameau, who was not only a musician but a philosopher, saw, or thought he saw, that there were certain natural properties in musical sounds which had a bearing on harmonic combinations, and he endeavoured, through the aid of some ingenious generalisations to show a connection between the two.

But his theory, though it had a philosophical foundation, did not go far; and since his day, the practice of harmony has taken a much wider development. Hence, later theoretical writers, trying to follow in his steps, have been obliged largely to supplement his simple principles by new and wider hypotheses of their own, of far more doubtful authority. And what has been the consequence? Simply the production of a host of theories and systems of harmony, so conflicting and inconsistent with each other, that, instead of establishing any useful and trustworthy foundation for practice, they have served only to promote endless and acrimonious controversy, and to make the study of the subject irksome and difficult. Instead of helping students on in their way, they have thrown stumblingblocks and pitfalls in their path.

The very name of theoretical harmony conveys to

musical students now-a-days an idea absolutely repulsive, not only on account of the complications it is made to involve, but from the feeling that the information, when gained, is unsatisfactory and untrustworthy, and of very doubtful practical use.

The fact of this absence of unanimity, in regard to the principles of harmony, seems to suffice of itself to suggest that the search for any natural basis on which to explain the whole complex structure of modern harmony is a mistake. No doubt, as Rameau found, there are, to a certain extent, natural principles which apply; but these are so overlaid by complications and additions of a purely artificial and æsthetical character, that the attempt to bring the whole structure under any immutable laws must necessarily prove a failure.

It is no disrespect to musicians to say that a good practical knowledge of the art does not necessarily imply an aptitude for investigating its philosophical conditions. In a late article in the "Nineteenth Century" (March 1878), "On the Reasonable Basis of Certitude," the author remarks: "It is a simple matter of fact that the enormous majority of mankind are entirely incapable of marshalling arguments or instituting a scientific inquiry into truth." And, in a case like this, it could hardly be expected that problems involving abstruse reasoning on complicated scientific data of a high character could be satisfactorily solved, except by those whose modes of thought have been trained by education and practice in a strictly philosophical school. It is on this account that the investigations of such men as Helmholtz acquire the highest value, and ought to command the most respectful attention.

Perhaps the best proof of the artificial nature of harmonical rules and systems generally, is found in the constant changes they are forced to undergo.

In this respect philology also furnishes a good analogy. Variations are constantly taking place, though slowly, in the forms of grammar, orthography, and pronunciation; and when they have come into general use, the *rules*, which are formed entirely *à posteriori*, must be changed accordingly. Similarly in music the same sort of variations occur, only much more rapidly. We have already had occasion to see how different the early harmony was from that of later times; and if we were to follow up the various changes, we should see each step of progress gradually superseding and altering the ideas and rules that formerly obtained. The rules that guided composition in the sixteenth century would be superseded in the eighteenth; as those of the latter-named period have been set at naught by the ideas of to-day. And it is quite possible that rules for composition at present in force may become as obsolete in the music of the future as those of the Middle Ages are now.

Instances are abundant where, certain rules having been supposed to be established on natural principles, it has only required the pen of a man of genius to abolish them for ever; and so to prove that their supposed natural foundation was only a delusion.

The process of investigation we are following will lead to the conclusion that musical forms have, for the most part, grown up by a gradual process of evolution under the hands of musical writers of different ages, and this process necessarily implies change.

It is necessary here, at the risk of repeating what has been said before, to point out what a great tendency there is, in theories of harmony, to rely too implicitly on the argument derived from the appeal to the ear. It is assumed that because certain harmonical forms are approved, and certain others are disapproved by our ears, there is therefore some natural reason why they should be so. But this assumption overlooks how completely we are, in

this respect, subject to the influence of habit and education.

No doubt, in the simplest elements of music, the ear has been the guide; and we shall see that there are physical and physiological reasons why certain preferences should have existed. But this appeal to the ear must not be carried too far; and when the ear is appealed to to sanction complicated effects of harmony, it amounts simply to begging the question. We approve certain things, not because there is any natural *propriety* in them, but because we have been accustomed to them, and have been taught to consider them right; we disapprove certain others, not because there is any natural *impropriety* in them, but because they are strange to us, and we have been taught to consider them wrong.

The case of literary composition gives here, again, a perfect analogy; bad grammar, or even bad pronunciation, is offensive to the ear of an educated person. But bad grammar, or bad pronunciation, implies nothing in violation of natural principles; and when we disapprove of them, we do so solely because they are contrary to the practice authorised by common usage, and which, consequently, we have been accustomed to approve.

If an appeal to the ear is to have any logical value, it ought to be made to a person unbiassed by any familiarity with the forms of music in actual use. If, for example, we could catch hold of a savage, who had never heard a note of music in his life, and try to get his judgment and opinion on these points of harmony by letting him hear them, the appeal might be conclusive; but the results would hardly be such as to corroborate the assertions made.

The fact is, this *argumentum ad aurem* is worth nothing unless it is carried further. If any harmonic effect pleases the ear, it must be either from physical reasons, or from æsthetical ones. If the pleasure arises from physical reasons, these ought to be shown (as they *can* be shown

in the simpler cases), and there is an end of the question. But if the pleasure arises from æsthetical reasons, then, as these will change with taste and education, they offer, not a natural, but only an artificial standard of right and wrong; and the appeal to the ear proves nothing conclusive as to their authority, or their permanence in the musical code.

This idea of the insufficiency and untrustworthiness of theories of harmony has long been entertained by thinking musicians, and it is countenanced by authority of far more weight than that of the writer of this work.

One of the greatest musical theorists of Germany who wrote in the beginning of this century, Gottfried Weber, took this ground in his theoretical works, and his principle has been well described in a single sentence:—"Weber only seeks to make the pupil acquainted with the chords that are used in music, and does not attempt to explain them or give their derivation."

And exactly the same may be said of the most modern German writer on harmony, whose work is probably now received as the most authoritative for teaching in that country, namely, Richter, the present head of the theoretical department at the great Leipsic Conservatoire. It is worth while to cite a passage from his preface:—

"This book contains no scientific theoretical treatment of the subject of harmony, but is devoted solely to a practical object, which would be very difficult to attain by the scanty scientific means at present available.

"It is true that demands have long been made for mathematical proof of musical rules, and this is especially the case with young students, who, rebellious against authority, would fain have everything subject to demonstration; and it is not to be denied that in this respect there is a blank in musical literature, which no one yet has succeeded in filling.

"No attempts of the kind have yet succeeded in devising a really trustworthy scientific musical system, according to which all the phenomena of music shall be shown to follow as necessary consequences from one fixed fundamental principle. And what philoso-

phers, mathematicians, and physicists have hitherto done, although very worthy of attention, has been insufficient for the purpose.

"Yet, when rightly looked at, this want only affects ripe and educated musicians, who willingly occupy themselves with theory: it is of little consequence to the earnest musical student. He has to direct all his powers to his technical training, in which he has rather to be taught the How than the Why. He must be taught rather to gather his principles from observation of the best examples, than to deduce them for himself; and it will be time enough for him at a later period to investigate further."

This is undoubtedly the most reasonable view of the mode of teaching harmony.

In the great new Musical Encyclopædia now appearing in Germany, giving the most advanced thought on all musical subjects, a distinction is carefully drawn between *Harmonie-Lehre*, the practical teaching of harmony, and *Harmonie-System*, the theory of harmony; and the author of the latter article, after showing the innumerable and contradictory theories that had appeared in Germany, remarks of them—

"Thus all these systems of harmony either rest on untenable assumptions, or are wanting in practical consistency; and they are altogether insufficient to explain the works of the acknowledged classical masters, much less to serve as critical standards for the compositions of the more modern school."

If any man would be competent to explain harmony by natural principles, it would be Helmholtz; but he gives unhesitatingly the same opinion. He says—

"The system of scales and modes, and *all the network of harmony founded thereon*, do not seem to rest on any immutable laws of nature. They are due to *æsthetical principles* which are constantly subject to change, according to the progressive development of knowledge and taste."

Again, alluding to the strict rules which are pretended to be drawn from theoretical considerations, he says (p. 554)—

"It is clearly a false position which teachers of harmony have assumed in declaring this or that to be *forbidden*. In point of fact

nothing musical is absolutely forbidden, and all rules for the progression of parts are actually violated in the most effective pieces of the greatest composers."

He also says—

"If any theory of harmony claims to have shown that all the laws of modern harmony are natural necessities, I should consider it to *stand condemned* as proving too much."

It is impossible to have more conclusive authority, or from a more competent source.

We may also refer, for confirmation of these opinions, to one of the most celebrated modern works on musical æsthetics, "Vom Musikalisch-Schönen," "On the Beautiful in Music," by Professor Hanslick, of the University in Vienna.[1]

Hence all classes of authorities appear to have arrived at the same opinion: namely, that it is vain to attempt to base all the rules of harmony on strictly scientific principles. We must be content with more moderate aims; we must investigate, by strict logical deduction, *what amount of natural basis* for them we can discover; and if we find a large residuum, which we shall be unable thus to account for, we must relegate it to the domain of æsthetics, where it must stand on different ground.

[1] For extracts, see Note C, at the end of this work.

CHAPTER XVII.

HARMONY CONTINUED.

C.—Elementary Combinations.

Having now seen how harmony has grown up, we must proceed to inquire into its theoretical nature.

This inquiry is by no means easy, for harmony is, in its full modern sense, a very complicated affair. It involves, in the first place, a great variety of combinations of sounds, differing exceedingly in their character, and the scientific analysis of which is of a very intricate nature. Also, although every substantive harmonic combination conveys its own independent idea, yet, in practical music, these ideas have to be linked together in a systematic and artistic way, so as to form a consistent whole. Hence we have to consider, first, the *combinations* of sounds individually; and secondly, the *progressions* from one combination to another. Both these subjects are ordinarily included in the study of harmony.

First, then, as to the principles on which sounds may be combined.

Of course many sounds may be used simultaneously, and we know that in practical music several notes are usually combined into one chord. But the simplest form in which harmony can appear is in the minimum combination of *two sounds* taken together.

These may be called *binary combinations;* and they are of much importance: they may, indeed, be conside elementary germs of all harmony; for when we names

look at the more complex combinations, we shall see that they may always be assumed to be formed out of these elementary germs, and that we shall find, in the latter, the simplest and most natural explanation of their structure.

Now, any two musical sounds may be combined together, and as the number of possible sounds is theoretically infinite, we might get an infinite number of binary combinations. But it must be recollected that we have a *definite musical scale*, on which we agree to form our music; and our investigation must, therefore, be limited to the combinations this scale will give.

A reference to the list of intervals on pages 77 and 78 will give an idea of the great variety of binary combinations that may be made in this way. The two notes of any interval, being sounded simultaneously, will give such a binary combination; and it will be found that, within the compass of one octave, the diatonic scale alone will furnish fifteen such combinations; and that, by supplementing this with chromatic notes, the number may be increased to twenty-three.

These combinations differ very widely from each other as regards their effect on the ear. Ever since harmony has had any existence, it has been understood that certain combinations of two notes are considered *more agreeable* than certain other combinations; and this idea has been expressed by the names attached to them of *consonances* and *dissonances* respectively. The binary combinations called consonances are seven in number:—the octave, the fifth, the fourth, the major and minor thirds, and the major and minor sixths. These, by their names, are supposed to be specially agreeable; all other combinations of two notes are called *dissonances*, and are supposed to be disagreeable.

It may naturally be asked, What is the reason for preferences? There may be a question as to the of the sharp distinction made between one class

and the other, and this will be treated of by and by. In the meantime, since the distinction between consonances and dissonances has become so firmly implanted in the theory of music, it will be advisable here to admit its validity, and to inquire whether any sufficient explanation of it can be found. Is there any physical reason why an octave, a fifth, or a third, should sound better to the ear than a tritone or a seventh? Have the words *consonance* and *dissonance* any *real significance?* or are they purely conventional?

This problem has been much puzzled over by philosophers, and the explanation most generally offered has been, that the preference is due to the *simplicity of the ratios* between the vibration-numbers of the two limiting sounds. The following table will explain this; and it may be added that there is a subordinate classification among the consonances themselves, the octave, fifth, and fourth, being termed *perfect*, and the thirds and sixths *imperfect*, consonances respectively.

CONSONANCES.

		Ratio.
PERFECT	Octave	2 : 1
	Fifth	3 : 2
	Fourth	4 : 3
IMPERFECT	Major third	5 : 4
	Minor third	6 : 5
	Major sixth	5 : 3
	Minor sixth	8 : 5

DISSONANCES.

Major second	9 : 8
Minor second	16 : 15
Major seventh	15 : 8
Minor seventh	16 : 9
Tritone	45 : 32

and so on for the others, all the numbers expressing the ratios of dissonances being high.

It must be explained that when the original names

were given, nothing was known about *vibrations;* but still the ratios had been determined by the *lengths of strings,* and it was assumed that for some obscure psychological reasons these might influence the ear.

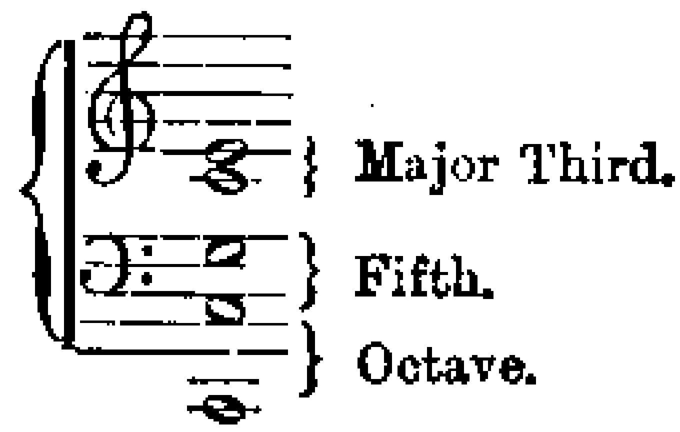
The earlier theories on this subject were extravagantly fanciful. Pythagoras, who first invented these ratios, was supposed to have derived them from the "music of the spheres," where, as he said, "all was number and harmony." This doctrine played a great part throughout the Middle Ages, and at a later time even Kepler, a man of the deepest scientific spirit, could not keep himself quite free from imaginations of the kind.

The celebrated mathematician Leonard Euler, in a book published in 1793 called "An Attempt at a New Theory of Music," endeavoured in a serious and more scientific manner to substantiate this theory of the simplicity of ratios on psychological considerations. He says we are naturally pleased with everything in which we can detect a certain amount of perfection and order, and that a combination of tones will please us when we can discover the law and order of their arrangement. Then, in proportion as this law is discovered more freely (which he thinks it may be when the ratios of vibration are simple, as in consonances), the mind will have more pleasure, than when (as in dissonances) the operation is obscure and difficult.

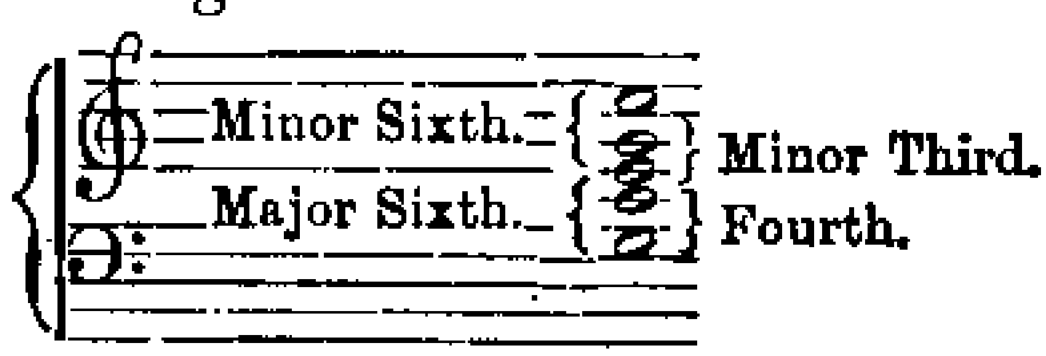
Euler worked out his theory with much ingenuity and in great detail; and it found general favour during the last century, although it certainly involved some difficulties as to the operation of the mind in appreciating the ratios in question, seeing that hearers of music in general usually knew nothing either about vibration-numbers or about proportions of strings.

Rameau made a much better attempt to explain consonance by pointing out that the more important consonances, namely, the octave, fifth, and major third, were contained in the natural harmonics of compound sounds.

This will be shown by a reference to the table of harmonics on page 40, in which the following relations appear:—



Rameau might have extended his explanation; for by looking a little farther in the same source he would have found the following:—



so completing the list of the consonances.

These considerations are very important; they enabled Rameau to construct an admirable theory; and we shall see their bearing better when we come to consider harmony more completely.

But, by giving the argument full scope, we shall find it proves too much; inasmuch as the natural scale of harmonics contains dissonances also, some even so harsh that they do not belong to our scale of music at all.

Helmholtz also raises the objection, that proving a thing to be *natural* does not prove it to be *agreeable*, or *beautiful*, or *desirable*; for we find in nature not only beauty but ugliness, not only help but hurt; and he instances many natural sounds that are anything but beautiful.

Hauptmann, the most modern writer on the theory of music before Helmholtz, ascribes the preference of consonances to metaphysical causes. He says—

"The octave is an interval in which the half of a sounding quantity is heard against the whole of the fundamental tone. It is, in its acoustical significance, the expression for the idea of *identity*, of *unity*, and of *similarity with itself*. It expresses that one-half agrees with its like, as the other half.

"The fifth is an interval in which a sounding quantity of two-thirds is heard against the fundamental tone as a whole. It signifies acoustically that something is *divided in itself*, and it therefore contains the idea of *duality*, and of an inner opposing element (*Gegensatz*); as the half sets a similar half outside itself, so does the quantity of two-thirds, when heard with the whole, denote the remaining third, a quantity in which the single appears to be set against the double.

"The major *third* is an interval in which a sounding quantity of four-fifths is heard against the fundamental tone as a whole. Here is denoted the remaining fifth, a quantity in relation to which the given quantity has a fourfold, or twice twofold, significance. In the quantitative meaning of *twice two*, inasmuch as the double is here taken together, as unity in the multiplicand, and likewise as duality in the multiplier, we find contained the idea of the putting together of the contradictory—of the duality as unity."

To what extent this kind of reasoning may be considered as a satisfactory explanation of the phenomenon of musical consonance, must be judged of by the reader.

It is of more importance to our argument, however, that Hauptmann appears in another place to doubt the positive nature of the distinction, for when he comes to speak of the imperfect fifth, he says (p. 39), after calling it dissonant—

"But here I must make a remark in regard to the idea of dissonance, namely, that the expressions often used, *wohl-klingend* and *übel-klingend* (*i.e.*, well-sounding and evil-sounding), are altogether improper to be used for *consonant* and *dissonant*. These latter contain in their etymological structure their full and accurate definition. The character of consonance is *sounding together* (*zusammen-klingen*); that of dissonance is *disunited sounding* (*auseinander-klingen*). Consonance may be evil-sounding in a place which requires a dissonance, and where the latter will sound well."

It is clear, therefore, that Hauptmann attaches the sense of the terms rather to the *use* of the combinations, than to the simple effect on the ear of the combinations themselves.

We now come to a more practical philosopher, Helm-

in musical acoustics, has endeavoured to solve it in a more satisfactory way.

It occurred to him that there might be something in the physical nature of the sounds themselves, when thoroughly investigated, which would account for their effect on the ear, and he succeeded in tracing this effect to the compound constitution of the notes used in the harmony. The essence of his explanation may be stated as follows:—

When two notes are sounded together, the harmonics or overtones of each are liable to interfere with each other, producing a certain *roughness or harshness;* and it is the greater or less liability to this which influences the *smoothness* of the combination, and gives it the character of a more or less consonant interval.

This is the general principle, but on account of the importance attached by Helmholtz to the discovery, it is necessary to illustrate it more in detail.

The roughness or harshness spoken of is due to the occurrence of what are called *beats.*[1]

When two musical sounds differing *slightly* in pitch are sustained together, the periodical coincidence of their vibrations gives rise to a certain *throbbing* or *beating* effect, recurring at regular quick intervals. It is an effect often heard in practice, and it may be produced easily by two organ pipes, intended to be in unison, but one of which is made a trifle sharper or flatter than the other.

The law determining the rate of this throbbing or beating is a very simple one. The number of beats per second will be exactly equal to the difference in the vibration numbers of the two sounds. Thus, for example, suppose two organ pipes sounding together, one at the rate of 256 vibrations per second, the other a little flatter, making 246 vibrations, there will be heard beats at the rate of ten per second. It follows, that when the two notes absolutely coincide in pitch, there are no beats; as they diverge, the

[1] See Note D, at the end of this work.

beats become quicker, and the effect of this is to produce impression of harshness or roughness on the ear. As the quickness increases the rough effect increases also, till the beats arrive at about thirty per second, which Helmholtz considers the maximum of harshness. As the velocity increases beyond this, the harshness diminishes, and when the beats become *very quick*, the disagreeable effect disappears. Hence thirty beats per second may be considered a sort of fixed point, at or near which the greatest degree of roughness is obtained.

The beats also increase in intensity in proportion to the *loudness* of the notes which cause them. Loud notes beating with a given velocity will produce a much rougher and more disagreeable effect than notes of weak power.

It is also necessary that the two notes must be sufficiently near each other to set the same elastic appendages of the auditory nerve in sympathetic vibration at the same time. If they are too far apart, the effect is too weak to admit of the beats being sensibly felt.

Now having given these data, velocity of beating, and strength and relative position of beating notes, we may examine some of the binary harmonic combinations of sounds, and see in what manner and to what extent the partial tones, of which the sounds are made up, give rise to the beating or harshness above described.

This may be clearly shown by diagrams. If we lay down, side by side, the sets of partial tones belonging to each note, it will be easy to see which of them interfere with each other; and if we add to each partial tone its proper vibration-number, we can at once get the velocity of any beat resulting therefrom. We have then further to take into account the comparative strength of the beats, and this may be roughly estimated by using a graduated size of note to represent the comparative loudness of the several partial tones. The fundamental notes are repre-

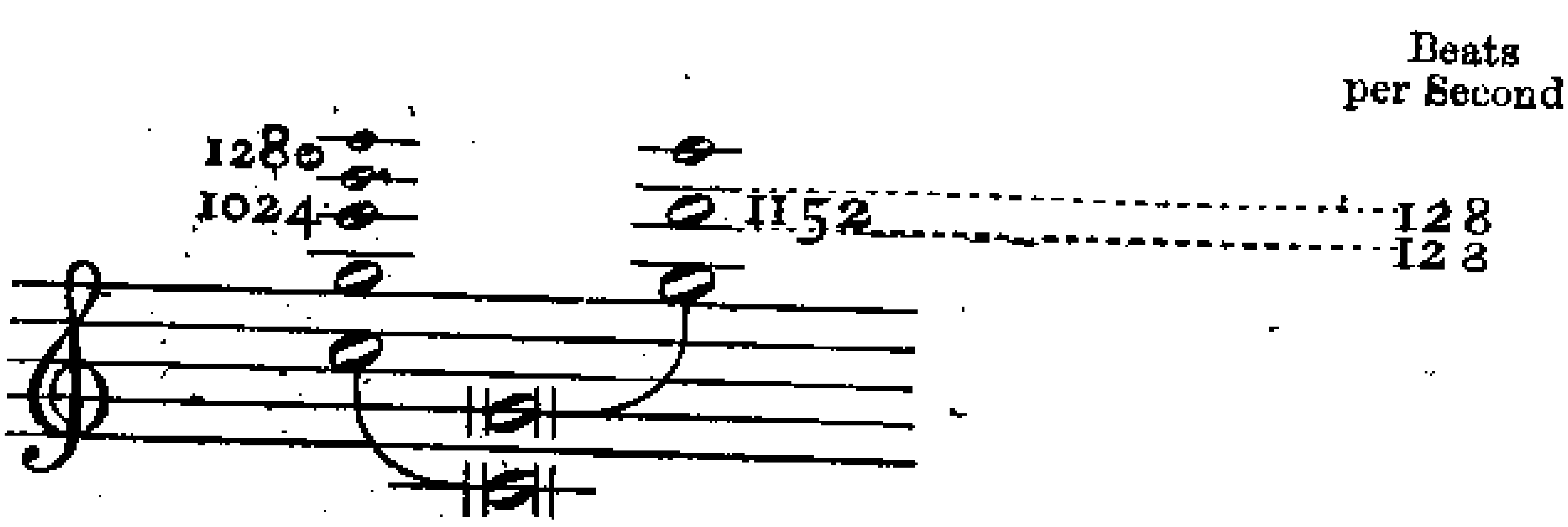
sented in the following diagrams by breves; the overtones by semibreves of sizes gradually diminishing as they ascend. We may confine the investigation to the five first overtones of the lower note; above this they are so weak that they may, for our present purpose, be neglected.

We will first take the simplest consonance, that of the Octave.

Here it will be observed there is no interference of any notes with others near them; in three places the sounds coincide, and simply reinforce each other, and the other two are quite free. There is therefore no beating or harshness; the effect of the combination is perfectly smooth; and hence the octave has the character of a perfectly consonant interval.

It will also be observed that the addition of the upper note introduces *no new sound*; it merely reinforces, by duplicates, sounds already belonging to the lower note. This is the explanation of the great similarity which the octave to a note bears to the note itself; the mind refusing to recognise any addition to the sensation received.

Now take the next consonance in order, the Perfect Fifth.

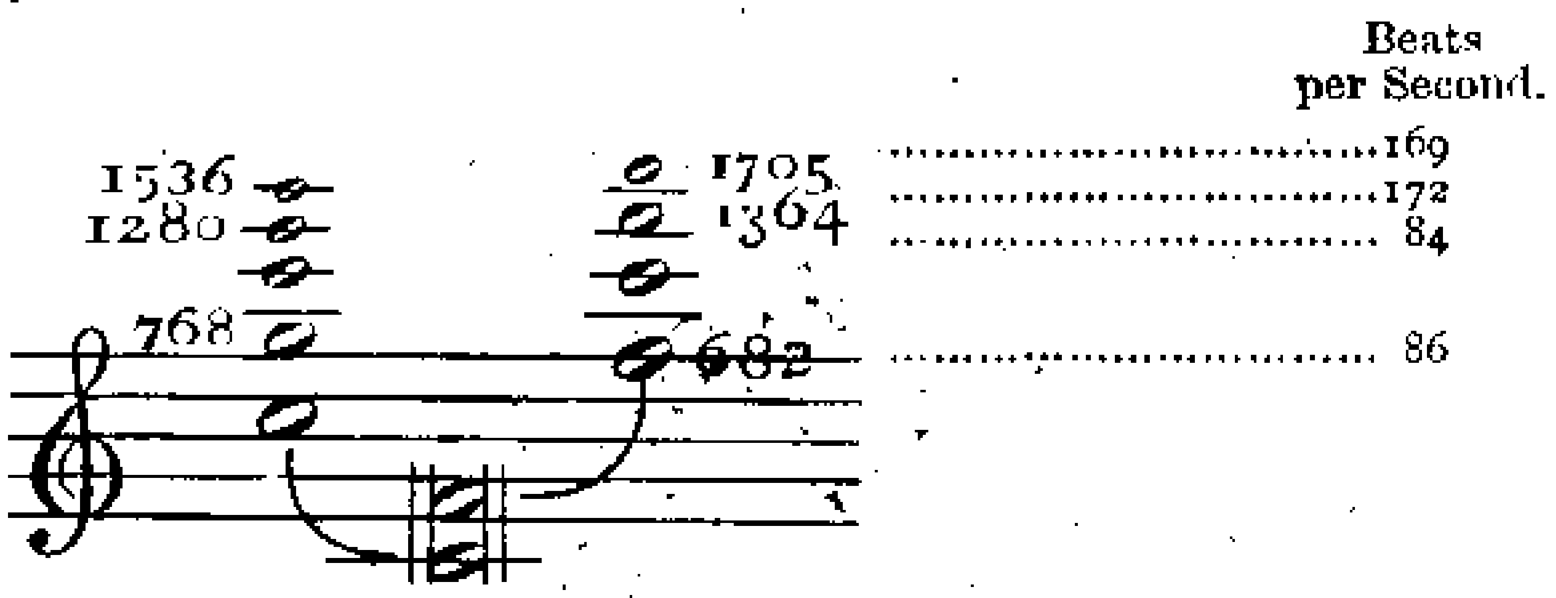


In this combination it will be at once seen that we have a different state of things from that of the octave. We have a D, the second overtone of the upper fundamental, sounding against a C and an E, the third and fourth overtones of the lower fundamental. This causes real interferences, and gives rise to two series of beats. The velocity of beating due to the C and D will be $1152 - 1024 = 128$ per second; that due to the D and E will be $1280 - 1152 =$ also 128 per second.

But these beats are very quick, and the roughness or harshness due to them is almost nil; consequently the combination of this interval, although not absolutely smooth like the octave, forms a very good consonance.

It will also be observed that the upper note adds *two new sounds* not contained in the series of the lower note; for which reason the ear at once appreciates the fifth as giving a new musical sensation.

Next take the interval of the FOURTH.

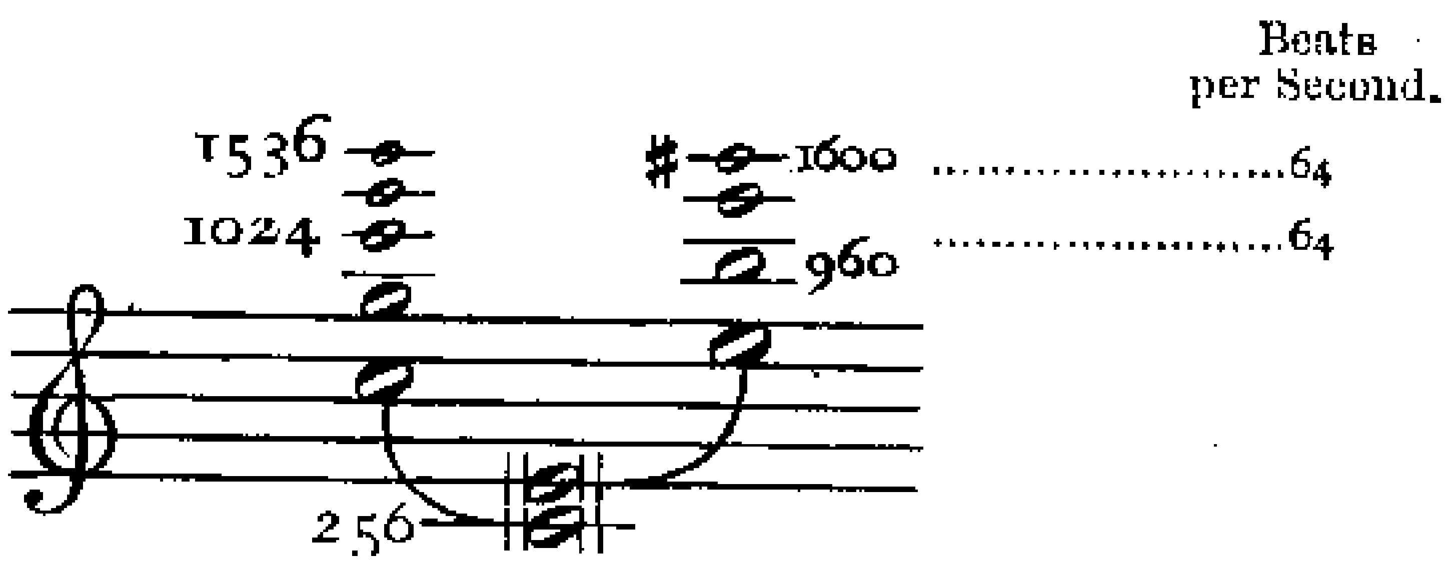


This is a little worse than the fifth. The two upper series of beats may be excluded, as they are very quick and between very weak notes. The two other series, 84 and 86, are more perceptible, but still they produce only a small degree of harshness, and the combination may well be deemed agreeable and consonant.

There has been a variation of practice about admitting the fourth as a consonance. The Greeks undoubtedly considered it so, and in the early days of harmony it ranked with the fifth; but about the thirteenth or fourteenth centuries, it was omitted from the list of consonances allowed in counterpoint, for certain reasons connected

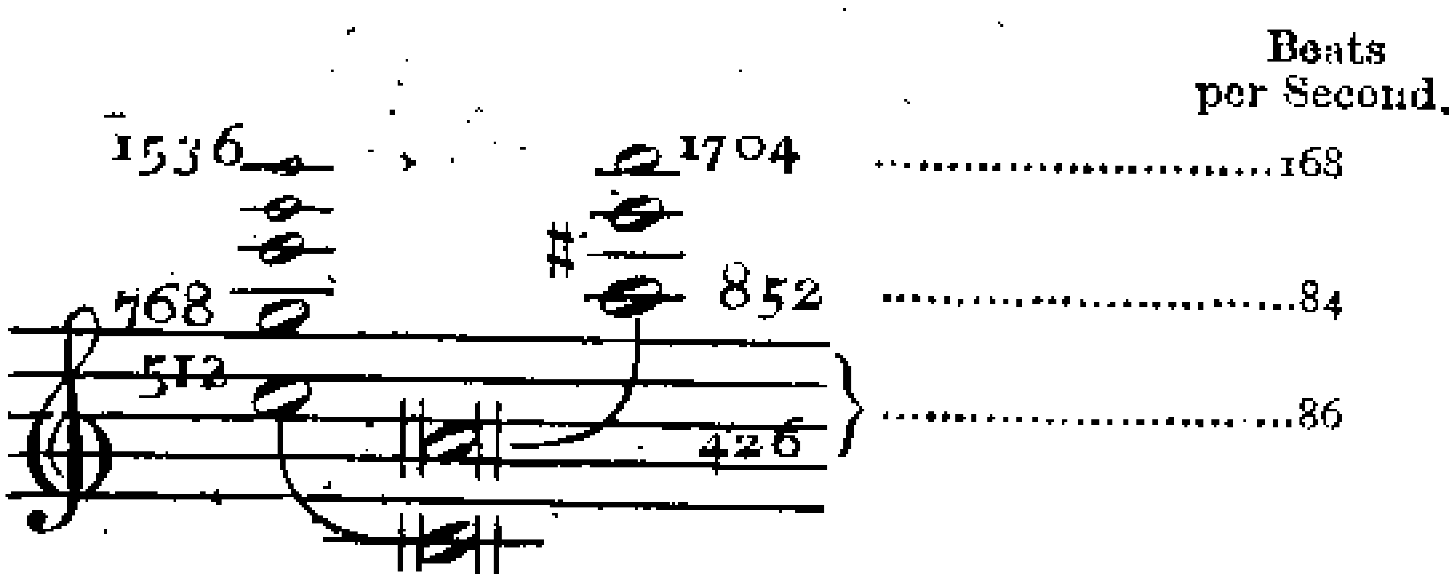
with the rules for the progression of parts, and which are explained by Helmholtz (p. 298). It is probable, also, that the fact of the fourth not being contained among the natural harmonics may have acted to its prejudice. There can be no doubt, however, that, taken by itself, the interval of the fourth is on acoustical grounds a good consonance, only a little inferior to the fifth, and superior to the thirds and sixths.

MAJOR THIRD.



Here the two fundamental notes and their octaves are probably too far apart to produce roughness; but in two higher places there are beats at 64 per second each. This is, therefore, a less perfect combination than the fifth; but still the beats are quick, and the effect is not disagreeable.

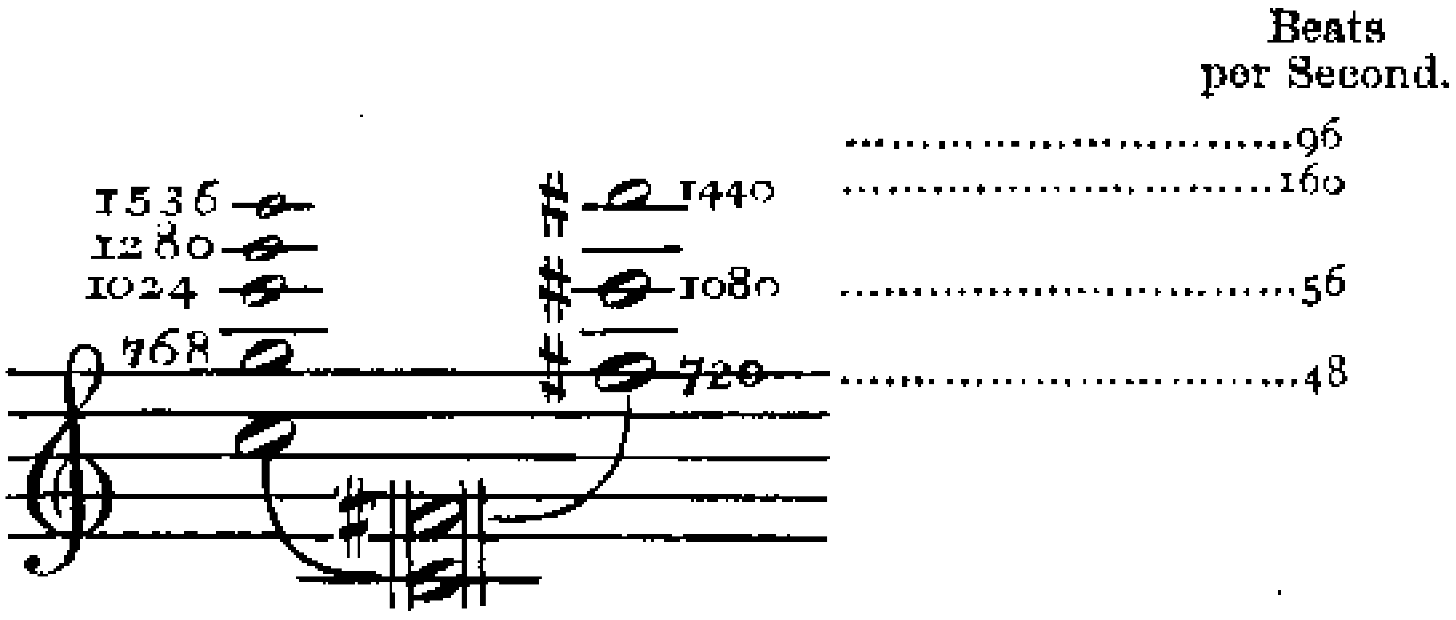
MAJOR SIXTH.



In this the beats are quicker than in the major third, and it also forms a good consonance.

Let us now compare with the above some of the binary combinations that are, in practice, considered less agreeable.

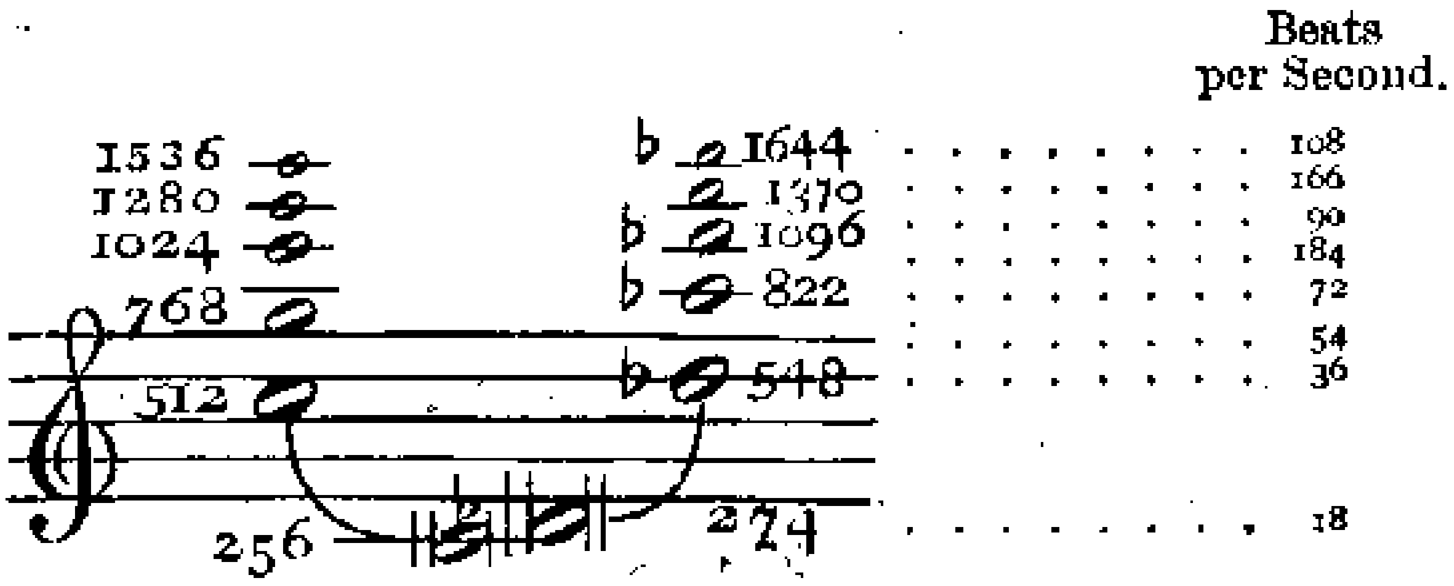
TRITONE.



Here some of the beats approach the harsher velocity, and are also caused by loud notes, the combination being clearly less agreeable than any of the former ones.

This interval is a dissonance in name, but is far less harsh than some others, as, for example, the following:—

MINOR SECOND.



Here every note beats strongly, and a very harsh dissonance is formed.

These few examples will suffice to illustrate the general proposition laid down by Helmholtz, which may now be given in his own words. He says (p. 294)—

"When two musical tones are sounded at the same time, their united sound is generally disturbed by the beats of the overtones, so that a greater or less part of the whole mass of sound is broken up into pulses of sound, and the joint effect is rough. This relation is called *dissonance*.

"But there are certain determinate ratios between vibration-numbers, for which this rule *suffers an exception*, and either *no beats at all* are formed, or at least only such as have so *little intensity* that they produce no unpleasant disturbance of the united sound. These exceptional cases are called *consonances*."

He adds (p. 342)—

"The essence of dissonance consists merely in very rapid beats. The nerves of hearing feel these rapid beats as *rough* and unpleasant, because every intermittent excitement of any nervous apparatus affects us more powerfully than one that lasts unaltered.

"Consonance is a *continuous*, dissonance an *intermittent*, sensation of musical sounds. Two consonant tones flow on quietly, side by side, in an undisturbed stream; dissonant tones cut one another up into separate pulses of sound."

Helmholtz has calculated the roughness of all possible intervals on certain practical data, and has ingeniously expressed the results in a diagram. It is unnecessary to reproduce this, as it gives more than is wanted here; but the English translator has adapted from it a list of the more usual intervals, in which their comparative roughness, as estimated by Helmholtz, is given in a numerical scale. The more important results of this table are given on page 222, which contains a list of the binary combinations most usual in music, arranged in the order of their respective degrees of dissonance.

Now the results of this investigation are very remarkable, and have an important bearing on the theory of harmony, as heretofore understood.

It has been the universal practice to make the broadest and most positive distinction between consonances and dissonances. The existence of such a broad distinction has hardly ever been questioned; it has been taken for granted, and has been adopted in all systems and rules of harmony as the basis, in a large measure, on which they are formed.

But if Helmholtz's results are correct (and we must recollect that his is the only theory we have that has any pretension to an intelligible physical basis), then this idea of the broad distinction between consonance and dissonance turns out to be a delusion. There is really only one perfect consonance; the *octave;* from this to

the extremest dissonances the steps are gradual, and no positive distinction can be made between the two classes of combinations. Indeed we actually find two combinations usually called dissonant among the consonances; the tritone proves not to be more dissonant than the minor third or minor sixth; and the extreme sharp sixth is less dissonant than either of them. All that can be said is that, generally speaking, the combinations called consonances are smoother and less harsh than the combinations called dissonances; but this is much less positive than the usual idea of the distinction.

The boundary between so-called consonant and dissonant intervals has varied at different times. The earliest intervals used in harmony were those that have been already mentioned as determining the natural divisions of the scale, namely, the octave, fifth, and fourth. We have already mentioned the old definition by Euclid that consonance is the blending of a higher with a lower tone; which he only admits as applying to these three: all others give rise to dissonance, which he defines as incapacity to mix, when two tones cannot blend but are rough to the ear.

After the Greeks got the true intervals of thirds and sixths, which we use now, they did not admit them as consonances: it was only at a later time, when the practice of harmony was extended, that this was done. And even then they were only called imperfect consonances; and the minor third especially was, down to a very late date, considered so imperfect a consonance that composers would not use it for a final chord.

It is a curious anomaly that in modern practice thirds and sixths are considered more agreeable intervals than octaves, fifths, and fourths, in the face not only of the above definition but of the physical characters of the combinations. This impression is by no means easy to account for. Helmholtz has attempted to explain it on the æsthetical principle that the mind takes more interest

in appreciating those relations which are more difficult of detection. He says—

"The resemblance of an octave to its root is so great and striking that the dullest ear perceives it: in fact, the octave merely repeats a part of the compound sound of its root without adding anything new. Hence the æsthetical effect of an octave is that of a perfectly simple, but little attractive, interval.

"The most attractive of the intervals, melodically and harmonically, are clearly the thirds and sixths: the intervals which lie at the very boundary of those that the ear can grasp.

"The major third and the major sixth can be properly appreciated when the first five tones of the compound are audible; and these *are* present in good musical qualities of tone.

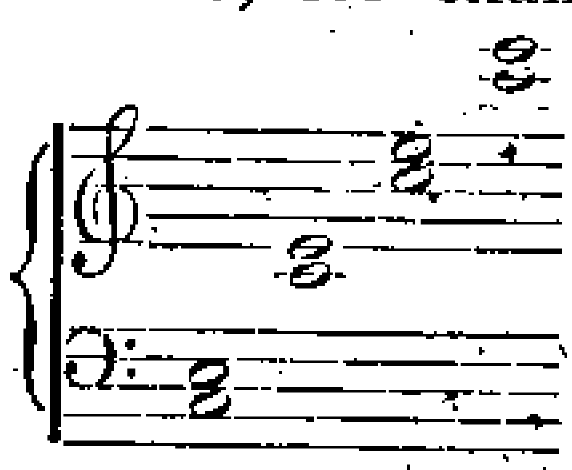
"The minor third and the minor sixth are, for the most part, justifiable only as inversions of the former intervals.

"The more complicated intervals in the scale have no longer any direct or easily intelligible relationship. They have no longer the charm of the thirds."

Whether this explanation is sufficient may be open to question; at any rate, it is the only one which has ever been offered.

The relations above given of different binary combinations, as regards their respective degrees of consonance, must be considered only as comparative, assuming the sounds to be taken at nearly the same pitch. It must now be explained that the positive degree of harshness of any given combination varies materially according as it is taken higher or lower.

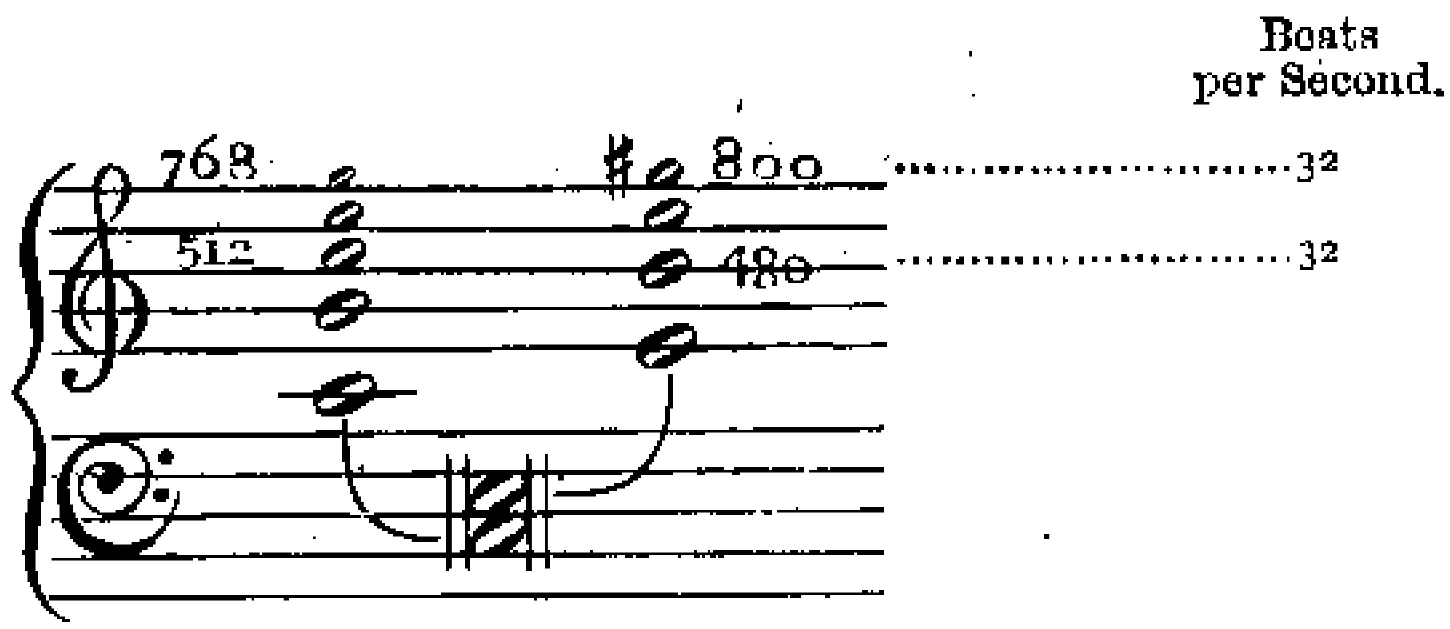
Thus, for example, the four major thirds following



all vary in the degree of harshness they offer to the ear; this being greatest in the lowest position, and diminishing in each one as it is taken higher.

This is a fact well known in musical practice: combinations and chords, which are excellent consonances in the upper part of the scale, become unendurable when taken in the low bass.

Helmholtz's theory affords (what was never given before) a very satisfactory explanation of this, as can be easily shown by an example. It will be seen by the diagram on page 213, that the major third, when taken in that position, gives rise to two sets of beats of 64 per second each, to which a small degree of harshness is due. But if we now transpose the interval an octave lower thus—



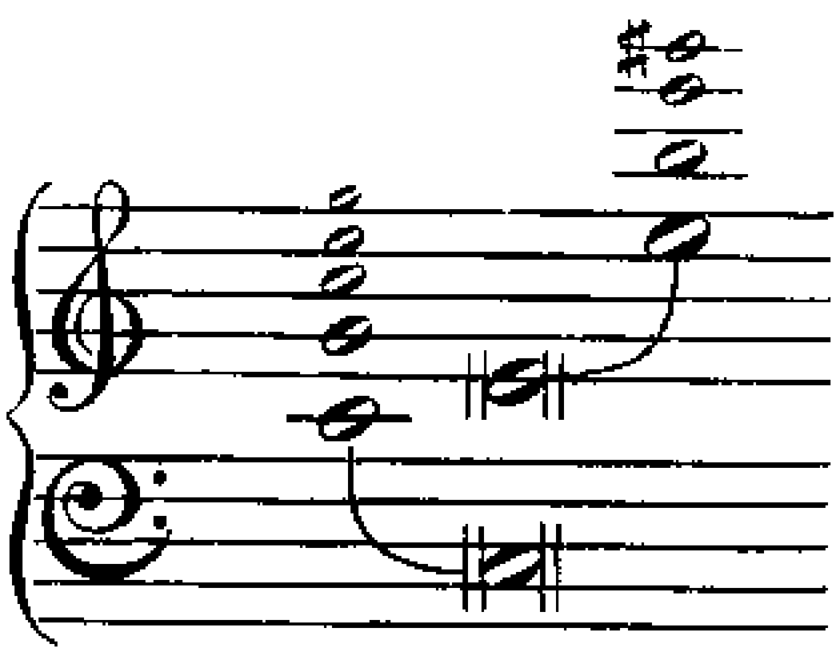
we find the beats halved in rapidity, beating about the maximum harshness, and much rougher by their lower pitch. A similar result would follow from the other changes, the raising of the pitch diminishing and the lowering increasing the harshness of the interval.

Another result given by this theory is, that the degree of dissonance of an interval will change materially when the notes are put wider apart by the interposition of octaves. Thus, for example—

In each of these the musician recognises the same interval of the major third, the ordinary definition of consonance not being changed by the change of position. But it is easy to see that, as the position of the harmo-

changed also; and hence the interval will acquire a new character as regards its consonancy or dissonancy by every such change of position.

To prove this let us make a diagram of the second position, and compare it with that of the first, which has been already discussed.



It will be seen that the effect of raising the upper note is to throw its overtones so high as to escape interference with those of the lower note, or at least with the most important of them; and hence the combination becomes much smoother. The exact nature of the changes produced in this way may be studied in Helmholtz, pp. 292 to 294.

The fact of a difference in effect by the spreading out of harmonies is well known in practical music, and is always taken advantage of in good composition.

Before leaving this elementary form of harmony it is right to mention a peculiar phenomenon which is connected with binary combinations of sounds, and which has an effect, in some cases, on the agreeableness or otherwise of the harmony. It is a *third sound*, spontaneously resulting from the combination of the others.

Let, for example, these two notes  be sounded on an organ, or some other instrument of sustained sounds. The interval must be perfectly in tune; for which reason an ordinary harmonium, or an organ tuned to equal tem-

perament, will not do. While these notes are sounding, let the experimenter listen very attentively, and he will hear, in addition, a third lower sound, thus— 

This third note is faint, and is difficult to catch by inexperienced ears, and a first trial requires careful and prolonged attention. When, however, the ear is accustomed to the appreciation of the sound, it can be caught quickly and easily.

Other binary combinations will give other resultant notes, and the rule for finding what they will be is a very simple one. The third sound resulting from any binary combination will be the note due to the *difference* between the vibration-numbers of the two original sounds.

The following table will illustrate this for the more common combinations:—

Attention was first prominently called to this phenomenon by the celebrated violin player, Tartini, about the middle of the last century. He attached so much importance to it that, in 1745, he wrote a treatise, founding on it a new system of harmony; and, what was of more use to the world, he made his pupils become thoroughly acquainted with this sound, to serve them as a guide to correct intonation in "double stopping," a point of instruction which has been revived lately under the sanction of Herr Joachim.[1] It will be remarked that, in all the simple cases given in the foregoing example, the third or resultant note forms good harmony with the two generating notes. When, therefore, the violin player is double-stopping, *i.e.*, sounding these two notes at once, if he listens for the

[1] Grundlage der Violin-Technik. Von Karl Courvoisier. Berlin, 1873.

resultant note, its accordance with the harmony or otherwise will furnish him with an easy and certain guide whether or not he is stopping in tune.

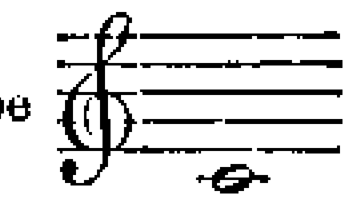
The sound above described has received several names: it is often called the *Tartini harmonic;* but it is also called the *grave harmonic*, the *under-tone*, or the *resultant-tone.* Tartini called it the *terzo-tuono*, or *third tone.* Helmholtz, from its vibration-number, calls it the *difference-tone*, and he makes some use of it in determining the consonance of chords, as will be shown in the next chapter.

The theory of this resultant tone is interesting. Dr. Young thought the grave harmonic was due to the coalescence of rapid beats, which linked themselves together like the periodic impulses of an ordinary *musical note;* and as this explanation harmonised, in the generality of cases, with the observed facts, it was, in spite of certain theoretical objections, for a long time generally received.

Helmholtz was the first to discover the true cause, namely, that vibrations which produce a certain practical amount of disturbance in the medium, give birth to *secondary waves,* which appeal to the ear as resultant tones. A full explanation of the theory will be found in his work.

On this principle, Helmholtz has also discovered that there ought to be, and actually is, another subsidiary sound resulting from each binary harmonic combination, which is always *higher* than the two primaries, and which has a vibration-number equal to their sum. This he calls a *summation-tone.* Its nature may be studied in Helmholtz's work, but it is not of such importance as to require further notice here.

TABLE OF THE COMPARATIVE DEGREE OF DISSONANCE, OR ROUGHNESS, OF DIFFERENT BINARY HARMONIC COMBINATIONS.

The lowest note of each combination is assumed to be 

Name of Interval.	Ratio.	Comparative Roughness.
TEMPERED SEMITONE . . .	$\sqrt[12]{2} : 1$	76
MINOR SECOND	16 : 15	70
MAJOR SEVENTH	15 : 8	42
AUGMENTED FIFTH . . .	25 : 16	39
MINOR TONE	10 : 9	38
MAJOR TONE	9 : 8	32
DIMINISHED THIRD . . .	256 : 225	30
DIMINISHED FIFTH . . .	36 : 25	28
DIMINISHED FOURTH . . .	32 : 25	25
AUGMENTED SECOND . . .	250 : 216	24
DIMINISHED SEVENTH . . .	216 : 125	
MINOR SEVENTH	9 : 5	23
MINOR SIXTH	8 : 5	
TRITONE	45 : 32	20
MINOR THIRD	6 : 5	
AUGMENTED SIXTH . . .	225 : 128	15
MAJOR THIRD	5 : 4	8
MAJOR SIXTH	5 : 3	3
FOURTH	4 : 3	2
FIFTH	3 : 2	
OCTAVE	2 : 1	0
UNISON	1 : 1	

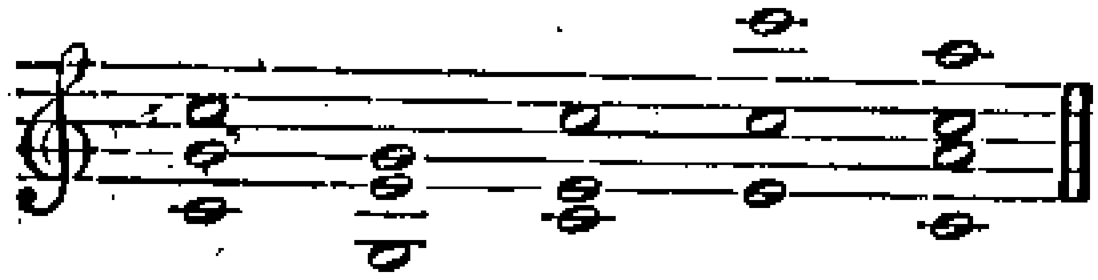
CHAPTER XVIII.

HARMONY CONTINUED.

D.—Compound Combinations, Chords.

In the last chapter we have treated of the effects produced in harmony by the simplest combinations possible, namely, those of two notes sounding together. But two notes are too few to produce what is understood as harmony in the modern sense of the term; to realise this there must be at least *three* notes sounding together.

And it must be explained that in estimating, in practical music, the number of notes of which a chord consists, it is customary to disregard *any duplication of a note by its octave,* and to consider the two together as one note. We have already had occasion to notice the great similarity there is between any sound and its octave, and the fact that the addition of an octave to any note introduces no new musical sensation; for this reason, the combination of a note with any octave above it is considered only equivalent, in chord construction, to the note itself. Thus the following combinations



would be considered as combinations of two notes only; and the following

as combinations of three notes only.

A combination of three or more distinct notes forms what is called a *chord.* The word is objectionable, on account of its similarity to the term for a stretched string, with which meaning it has no connexion. It is derived from the French "accord," which has no equivocal signification. We have, however, in English no other word to express the idea, and must be content to use the one sanctioned by custom.

There is much difference of opinion as to the modes of considering chords. The usual idea of theoretical writers on harmony seems to be, that it is absolutely necessary to find out some mode of *deriving* them, or accounting, on some presupposed principle, for their existence, their form, and their properties. The mode of derivation of chords is, in fact, the *quæstio vexata,* the great stumblingblock, in all empirical systems of harmony. This point will be better illustrated hereafter; in the meantime, it is desirable to consider chords in the simplest possible way.

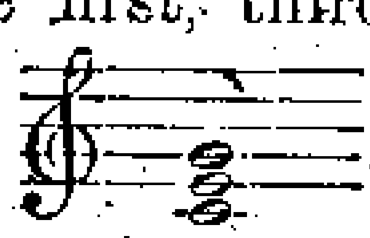
It will be evident that all combinations of three or more sounds may, by the easiest process of analysis, be resolved into elementary binary combinations of the kind described in the last chapter: in other words, they may be considered as *compounded* of several of these binary combinations taken together; and it follows that the character of any chord will be indicated in the simplest and most logical way by the characters of the several elementary combinations of which it is composed. For we have found, in the last chapter, that the various elementary combinations have, each separately, a certain effect on the ear; and it is clear that in a compound combination or chord we shall have several of these combined.

This, therefore, is the way we shall here study chords; it is, in fact, the only mode by which we can bring physical analysis to bear upon them; it involves no theory of derivation in any way, being merely an exposition of facts lying clearly before the eye.

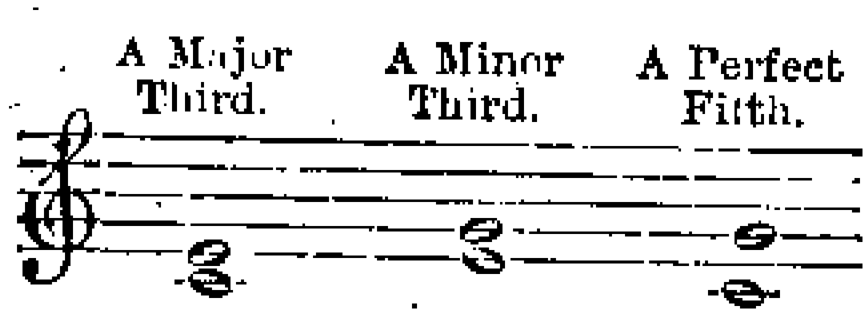
We have then to consider what compound combinations shall be selected for discussion, and in this we may fairly be guided by the facts of practical music. No doubt any three or more sounds in the infinite gradations of pitch might be combined together, but it would be useless to discuss the imaginary combinations of all possible tones; we may more usefully limit our attention to those which we actually meet with in practice, and which are formed from notes already existing in the acknowledged musical scales. These may be divided broadly into two classes: those formed from the diatonic scale only, which may be called Diatonic Chords; and those requiring the introduction of chromatic notes, which may be called Chromatic Chords.

Diatonic Chords.

Major Triad.

The best-known combination of three sounds is formed by taking the first, third, and fifth notes of the major scale; thus— 

This, it will be at once seen, contains three elementary or binary combinations—



The investigations of the last chapter show that these are all consonant in a high degree, and therefore we may conclude that the compound combination ought to be agreeable, which is in perfect accordance with practical experience. Any chord formed by combining a note with

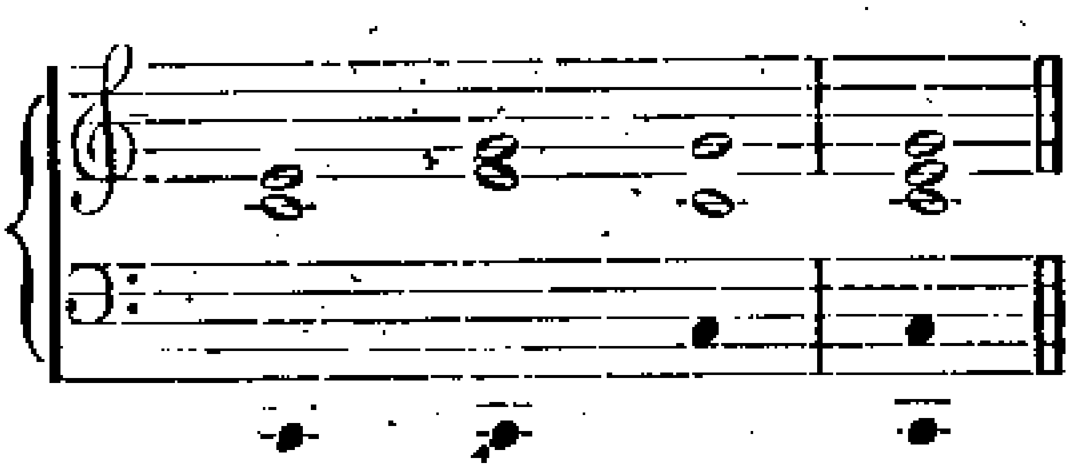
its third and fifth is called a *triad*, this being distinguished as the *major* triad, by the character of its third. It is also, from its very frequent use, called the *common chord*.

It is possible to assign to the chord a numerical value representing its character for consonance; for as we have, in the last chapter, found the degrees of consonance (or rather of dissonance) attached to each binary combination, we have only to add together such of these as make up the chord in question, to express the character of the combination. Thus—

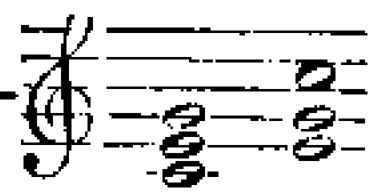
	Degree of Dissonance.
Major third, ...	8
Minor third, ...	20
Perfect fifth, ...	0
Resulting degree of dissonance of the major triad,	28

which we shall see, when we come to compare it with others, is but slight, showing an agreeable chord.

We must also, in determining the degree of consonance of a chord, take into account the effect of the *additional combination tones* that may be produced by the several binary elements. The following diagram shows the Tartini or grave harmonics generated by the three binary elements of the major triad:—



That is, the combination tones merely result in the addition to the chord of two C's below it, which, blending perfectly with the harmony, do not interfere in the least with it, but, by strengthening its fundamental note, rather improve it than otherwise.

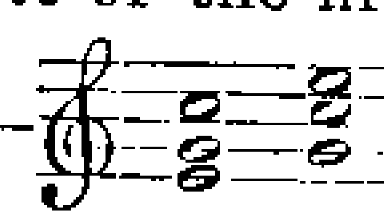
chord, by changing the position of one note to its octave above, thus— 

The latter form is called, by practical musicians, the *first inversion* of the major triad, or the *chord of the sixth.* We have seen that on account of the similarity between a note and its octave we consider them in harmony as identical, and thus the chord remains essentially the same.

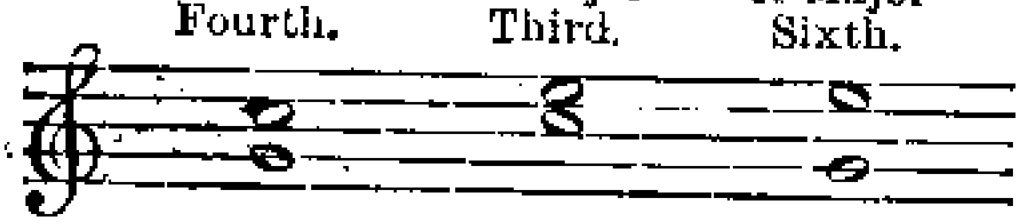
The change, however, produces some difference in the binary elements of the chord. It is now made up of—

These are still all consonant, and the chord does not lose its agreeable effect, although its character is slightly changed. The numerical degree of dissonance is—

Minor third, ...	20
Perfect fourth, ...	2
Minor sixth, ...	20
Degree of dissonance of the first inversion of the major triad	42

Again, we may take away the lowest note of the first inversion, and put it an octave higher, thus— 

This constitutes the *second inversion,* or what musicians call the chord of the *sixth and fourth.* Its elements are—

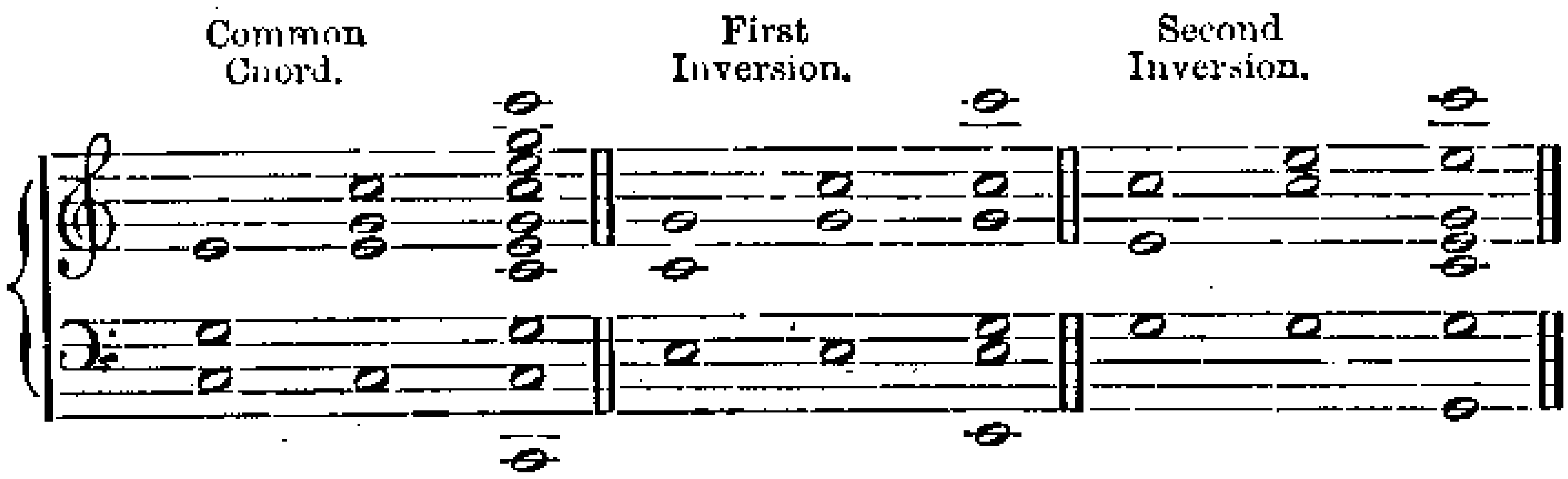


and its numerical value is—

Fourth, ...	2
Major third, ...	8
Major sixth, ...	3
Degree of dissonance of the second inversion of the major triad, ...	13

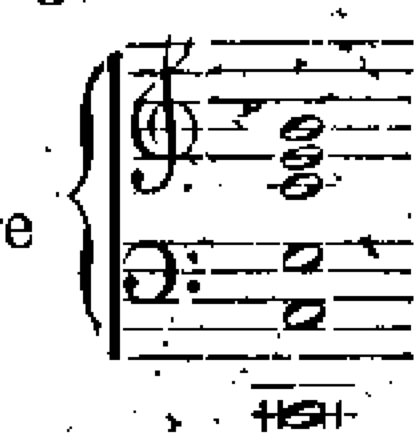
showing that the chord is agreeable in whatever position it be taken.

We may make many changes in detail, by octave substitutions or duplications, thus—



But, so long as the notes are C, E, and G, the chord remains essentially the same.

Now there is a peculiarity about this chord which is very important, and which belongs to no other. It has a direct natural origin. It exists, not only theoretically, but practically and audibly, in the most prominent partial tones of every brilliant musical sound.

A reference to the table of partial tones on page 40 will show that, taking a fundamental note C, the six first partial tones of it are  which will be at once identified as forming the major triad we are now describing.

It is a result of our daily experience and observation, that these several notes blend so smoothly and completely into one compound sound that it is difficult for the ear to distinguish them separately; and hence this chord has always been recognised as forming a naturally agreeable harmony, and has assumed such an important position in music.

The existence of the major triad in natural compound sounds was known long ago; but its application to the

theory of harmony is due entirely to Rameau, and was his great merit in this respect.

It was he also who first gave importance to the idea, that all the varieties of position and inversion of this chord might be classified as one and the same harmony, springing from one fundamental note. This idea immensely simplified the theory of harmony; and it has formed the basis of all modern instruction.

Rameau carried his theory out into a good deal of detail, endeavouring to make it explain, not only the common chord major, but many other facts of harmony. We shall have occasion to notice several of his views hereafter.[1]

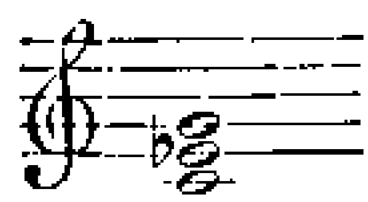
It is a consequence of this derivation of the major triad, that one of its notes should be of special importance; namely, the note which corresponds with the *fundamental* of the compound sound. In the examples given above, this important note is, of course, the note C. This fundamental note is now universally called in England the *root* of the chord. It is not clear who first used the term; but it was not Rameau, who called it by a more appropriate name, *générateur*. The word "root" must have been introduced by some one after him; and it is very necessary to understand thoroughly its bearing, because the term, although proper enough here, has been misapplied in other cases, to the great confusion of the theory of harmony.

The common chord major consists of certain notes which spring naturally, in a compound sound, out of a certain fundamental, in the same manner as a plant springs from its root; and from this analogy, the note corresponding to this fundamental may be fairly called the *root* of the chord. We shall have occasion to call this definition to mind farther on.

[1] Rameau's original work of 1722 is exceedingly prolix and difficult to follow; the subsequent adaptation, M. Rameau, eclaircies, développés et simplifiés, par M. D'Alembert, 1752," is much preferable, and is the one

It follows from this that the most natural and satisfactory position of the common chord is with the *générateur* or *root at the bottom*; and for this reason every piece of music *closes with a common chord in this position.*

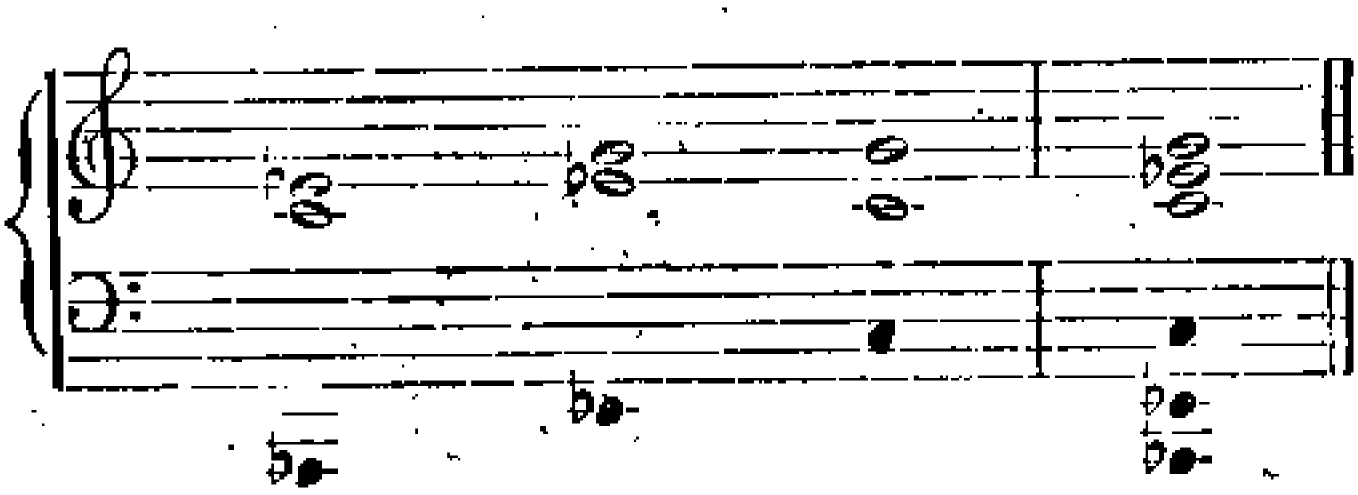
Minor Triad.

The chord next in importance is very much like the former in appearance, but it has one note changed. The third from the key-note of the scale is minor instead of major, for which reason it is called the *minor triad*, or common chord minor. 

It contains in this position the same binary combinations as the major triad, but arranged differently, thus—

These, put into numerical values, bring out the same degree of consonance as the major triad in the same position; and this so far corresponds with practice that the minor triad is always held by musicians to be a consonant chord.

Still, however, it is undoubtedly less satisfactory to the ear than the major triad. One reason for the inferiority arises probably from the different effect of the combination tones, or Tartini harmonics. We have seen that in the major triad these are perfectly harmonious. This is not the case in the minor triad, as the following diagram will show, the combination tones being given in black notes:—

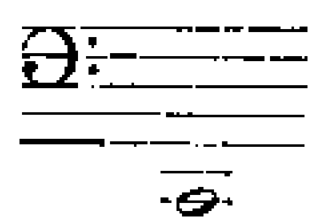


It will be seen that among the resultant tones is an

A♭, which is clearly foreign to the harmony, and gives harshness to the chord.

But there is another and probably a more powerful reason why the minor chord is less satisfactory than the major, namely, that by the substitution of the E♭ for the E♮ it loses its direct natural justification. It is no longer prominently suggested by the natural harmonic combinations of compound sounds.

Considering, however, the very general use of the chord, musicians have been reluctant to admit that it is an artificial combination, and many attempts have been made to prove its natural origin.

One is deduced from the fact that although, as above stated, the minor triad of the fundamental is not prominent in the harmonic scale, yet a similar chord does exist in the series. By referring to the diagram on page 40, chap. iii., it will be seen that the tenth, twelfth, and fifteenth partials of the fundamental sound  give the notes  forming the chord in question.

But, in the first place, these harmonics are so remote that they are very seldom prominent enough to be heard; and if they were audible, it would be scarcely possible for any ear to separate them from the confusion of neighbouring tones so as to gather from them the impression of a distinct harmonious combination. So that, although the minor triad may be *conceived* to be present in these partial tones, it is out of the question that it should ever have been practically suggested by them.

Again, it happens that the *nineteenth partial tone* of C is very near to E♭, and this has been used as an argument for the natural existence of the minor triad of C in the compound sound of the same note; but this harmonic is so distant from the fundamental, that it could never have been discovered by the practical ear, and could

have had no influence in determining the origin of the chord.

Rameau, endeavouring to make the natural harmonics of a sounding body explain everything in music, accounted for this chord by pointing out that E♭ as a generator would give G; and C as a generator would also give G. Hence, by supposing *two* generators, the minor triad would be given by nature, although he admitted it was given "less directly than the major triad."

This is right enough as far as it goes; we take a binary combination, C G, from one natural triad, and we take another binary combination, E♭ G, from another natural triad, and, rejecting the other notes of each, we put these selected portions together. But this is clearly an *artificial* operation, and in adopting it we give up the idea of the natural derivation of the minor chord as a whole.

At the same time, Rameau's principle of looking at intractable chords as combinations of portions of other chords is a very ingenious, sensible, and simple one; it will explain almost anything, and it is surprising that, in the great anxiety shown by musicians for derivations and roots, it has not been more employed. We shall see its applicability to a great many cases as we go on.

Hauptmann makes some curious metaphysical distinctions between the major and minor triads (p. 29 *et seq.*), which, however, need not be quoted here. He considers the former as an active principle, determining or defining; the latter as a passive principle, determined or defined. He likens the minor chord to the branches of the weeping willow, giving a mournful impression.

Helmholtz has devoted some attention to this question. He says (p. 454)—

"In the minor chord, C E♭ G, the G is a constituent of the compound tones of both C and E♭. Neither E♭ nor C occurs in either of the other two compound tones. Hence it is clear that G at least is a dependent tone. But, on the other hand, this minor chord can be regarded either as a compound tone of C with an added E♭, or a com-

pound tone of E♭ with an added C. Both views are entertained at different times, but the first usually prevails. If we regard the chord as the compound tone of C, we find G for its third partial, while the foreign tone E♭ occupies the place of the weak fifth partial E. But if we regarded the chord as a compound tone of E♭, although the weak fifth partial G would be properly represented, the stronger third partial, which ought to be B♭, is replaced by the foreign tone C. Hence in modern music we usually find the minor chord, C E♭ G, treated as if its root or fundamental bass were C, so that the chord appears as a somewhat altered and obscured compound tone of C. But the chord also occurs in the position E♭ G C even in the key of B♭ major, as a substitute for the chord of the subdominant E♭. Rameau then calls it the chord of the 'Great Sixth,'[1] and more correctly than most modern theoreticians, regarding E♭ as its fundamental bass."

He further (p. 552, &c.) alludes at some length to the hesitation which the old composers had to *close* with a minor chord; and thinks it was ultimately only admitted from a feeling that it was a chord of the tonic only obscured by the alteration of the third. He thinks the peculiar æsthetic expression of the minor mode may arise partly from its imperfect tonality, and partly from the heterogeneous combinational tones which must accompany it, as already explained.

English writers on harmony usually give C as the "root" of the minor triad, C E♭ G, without hesitation, from its analogy with the major triad; but it must be pointed out that in doing so they lose sight of the original and true meaning of the term *root*, which was, undoubtedly, a fundamental sound out of which the chord in question would grow or be developed by the natural compound harmonics. In this, while following Rameau's idea, they have carried it too far, and given the term a meaning which he never intended, and which certainly is not justified by philosophical reasoning. In fact, there is only one chord which has a *root* properly so called, *i.e.*, the major triad;

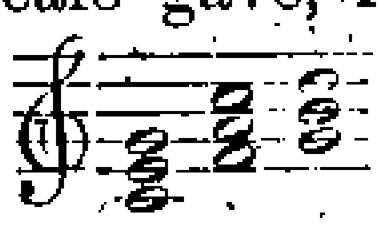
[1] Mr. Ellis translates this "Major Sixth," but this is an error; Rameau's expression is "Grande Sixte," which is quite a different thing.

if the word is applied to any other combination of notes, it must be by some other conventional interpretation.

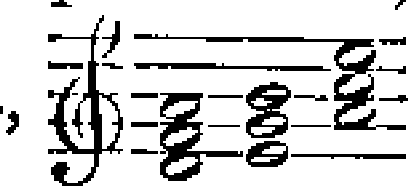
The German writers do not use the term in the sense we do, or if they have done so, the more modern ones have given it up; for Richter carefully avoids any such use of the term. The word *Grundton,* which he occasionally uses, and which is the only one analogous to it, merely means the *lowest note of the chord* in what he considers its original or normal position,[1] and not, as the English understand it, an imaginary note indicating a supposed *origin* of the chord. The term, for example, would be quite properly applied to *parts* of chords in Rameau's method; but it would lead, in all cases except the major triad, to the necessity of assigning several roots to one chord, as, in fact, Rameau and Helmholtz have done.

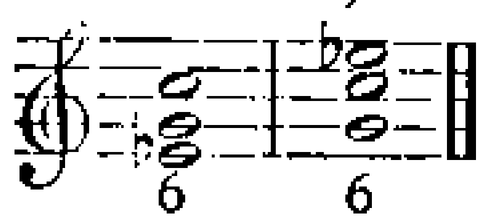
It has been necessary to give somewhat full explanations on this point, because the search after what are called the "roots of chords" constitutes one of the greatest difficulties of theoretical systems of harmony, and gives rise, for the most part, to the conflicting theories and unsatisfactory results which we encounter in them.

The minor triad is the simplest instance of this difficulty. In the philosophical sense, the chord can have no single root; it must have two.

But one is led to ask, Why need we trouble ourselves about any root at all? The chord requires no justification, nor does its origin need much explanation; it would arise quite naturally, in the first instance, out of the combinations of notes in the ordinary scale, as brought about by the movement of the contrapuntal parts. And when harmony took an independent form, its importance would be confirmed by its consonant nature. It would be found that the diatonic scale gave, from its own proper notes, three major triads,  and these, being the most

[1] Helmholtz says (p. 515) the normal position of discords is taken to be that which arranges their tones as a series of thirds.

agreeable combinations, would have the first preference; but the scales also contained three minor triads,  and these, being also found consonant, would take the next rank; after which would come the dissonant combinations or discords. It certainly would seem that to seek further justification, or derivation, or proof of origin, is merely supererogation, and can lead to no useful end.

The minor triad, like the major, admits of two inversions— 

In these the degrees of dissonance, determined by the binary combinations, are—

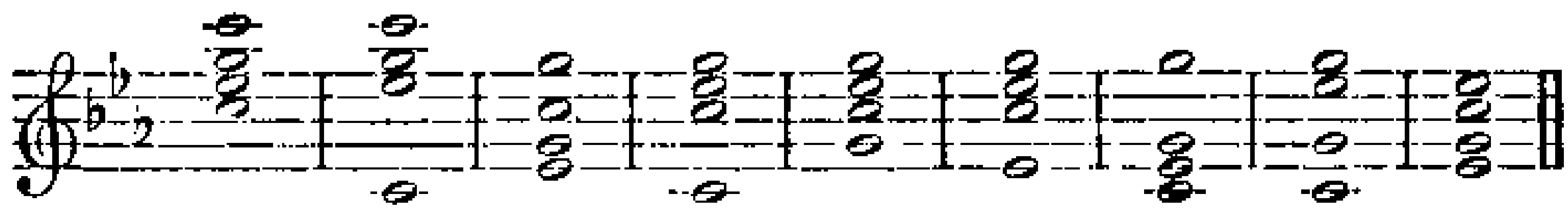
For the first inversion, ...	13
For the second inversion, ...	42

showing that, although the chord in any position is good, the degree of goodness varies somewhat with the position in which it is taken.

Helmholtz has carried farther the investigation how far the positions of the major and minor triads influence their smoothness. He has taken into account other more complicated causes of interference, and has given (p. 332 *et seq.*) a list of various positions of the chords arranged in their order of comparative roughness. He has done this for the three notes simply, and also for the same chords in four parts, *i.e.*, with one of the notes doubled in octaves. A table of the latter may be given as an example—

MAJOR TRIADS.

MINOR TRIADS.



1 2 3 4 5 6 7 8 9

These are numbered in order of preference: the first being considered the best, the last the worst.

All this is, no doubt, true as a matter of philosophical reasoning; but it is not of much importance in a practical point of view. In all cases where the practical difference in effect on the ear is material (and it is probably not very great in any of them), the better harmonies will recommend themselves naturally to the composer, and he will use them when he desires.

But music cannot in practice be so limited, and what are put down here as the harsher sounds, are as essential to composition as the smoother ones. Indeed, the problem of composing music now-a-days involves such a host of heterogeneous elements and conflicting considerations, that the portion of them which can be influenced by these refined calculations becomes infinitesimally small.

The two chords above described, the major and minor triads, are the only *consonant* compound combinations in harmony; all others are more or less dissonant. It has been already pointed out that the notes of the ordinary diatonic major scale furnish six of these triads, three major and three minor; every piece of music uses them plentifully, and, in fact, they form generally the staple of musical composition. They have, from their nature, a character of smoothness and repose, each chord conveying in itself a complete and satisfactory idea to the mind.

But concords only are not sufficient to meet the demands of modern musical taste. It is not opposed to the æsthetic ideas of propriety, that the smoothness of effect

produced by concords should occasionally be broken, provided certain conditions be fulfilled; and this is done by the introduction of harsher combinations called *dissonant harmonies or discords.*

Helmholtz, in regard to these, says (p. 516)—

"Dissonance cannot be entirely excluded, because consonances are physically more agreeable.

"Though the physically agreeable is an important adjunct and support to æsthetic beauty, it is certainly not identical with it. On the contrary, in all arts we frequently employ its opposite, the physically *disagreeable*, partly to bring the beauty of the first into relief, by contrast, and partly to gain a more powerful means for the expression of passion.

"Discords are used for similar purposes in music. They are partly means of contrast, to give prominence to the impression made by consonances, and partly means of expression, not merely for peculiar and isolated emotional disturbances, but generally to heighten the impression of musical progress and impetus; because, when the ear has been distressed by dissonances, it longs to return to the calm current of smooth harmony."

Discords are very various in their nature: they may either consist of real substantive *dissonant chords;* or they may be formed by the introduction accidentally of dissonant notes, which may occur in various ways, as will be hereafter explained.

We must begin with the real dissonant, independent harmonies.

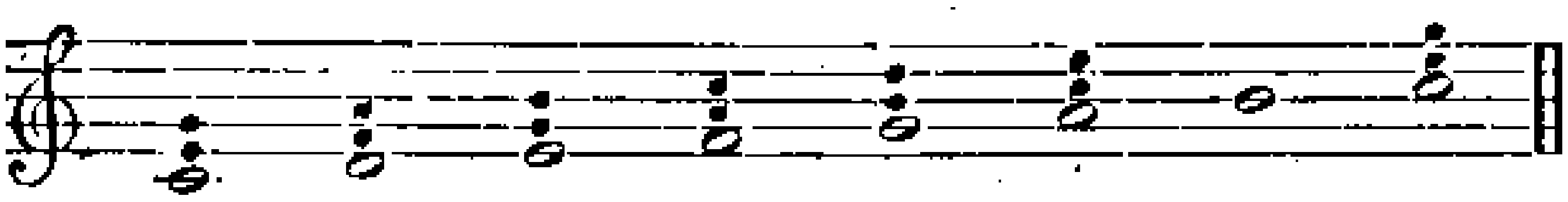
There are great differences of opinion among writers on harmony, as to how dissonant harmonies should be treated and classified; indeed, the different "systems" of harmony which have been promulgated chiefly depend on varieties in this respect, and the greater part of the controversies have had reference thereto. These controversies and differences of opinion have almost always been caused by the search after "roots." The idea, so constantly present in the minds of theorists, that every chord must be capable of derivation from some particular note, involves increased difficulties in regard to discords; and has, consequently, led to more frequent disputes.

We must, however, here proceed on the principle already laid down, that the idea of a single root or generator is inapplicable, on physical principles, to any chord except the major triad; and that if it is thought desirable to refer to roots at all, it must be done on the principle of Rameau, namely, by dividing the chord off into separate portions, and assigning a separate root to each.

The dissonant combinations which it is possible to make on the various notes of the scale are very numerous, and are largely increased when, as is usual in modern music, chromatic additions are called in. It will be desirable briefly to notice the combinations in most common use, beginning with the diatonic chords.

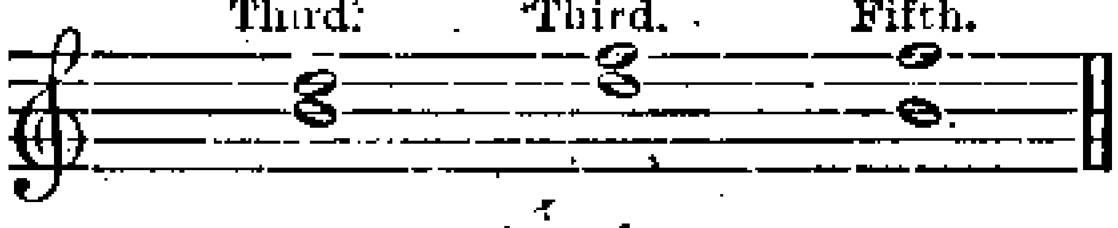
The Diminished Triad.

We have seen that consonant triads, either major or minor, may be formed on six notes of the scale:—



But what about the seventh note? Why is that exceptional? For this reason, Because each of the concordant triads, as will be recollected, had a *perfect* fifth, whereas here the fifth, B to F, is a *diminished* fifth.

Hence this combination  though in appearance resembling the triads already mentioned, is of a different character from either of them. Its binary components are—

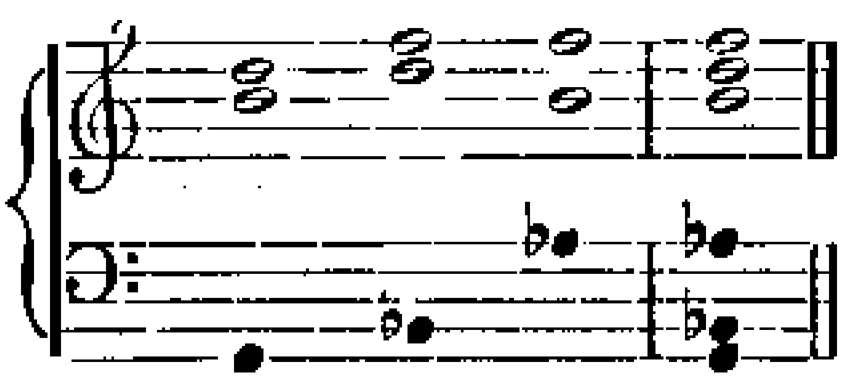


and the numerical values are—

Minor third	20
Minor third	20
Diminished fifth	28
Degree of dissonance of the whole chord in this position	68

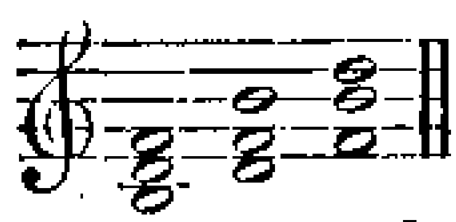
This, it will be seen, is much harsher than either of the concords in the corresponding position; and as one of the binary elements is called dissonant, the whole chord is called a *dissonant chord* or a discord, and, taking its character from the imperfect fifth, it goes by the name of the imperfect or *diminished triad.*

Another cause of the harshness of this chord is due to the difference-tones, which are as follows:—



the difference-tones giving a combination manifestly inharmonious.

The chord admits, like the triads, of two inversions—



all three positions being much used. In the inversions, the dissonant interval changes from the diminished fifth to the augmented fourth or *tritone.* The values of these will be seen in the general table given hereafter.

The diminished triad has a very peculiar property, namely, that it determines *the key* of any musical passage in which it occurs, the reason being that there is only *one* diminished triad that can be formed in any diatonic scale.

We may have (as we have seen) three major triads and three minor triads: and it is a necessary consequence that either of these may belong to three scales. For example—

The Major Triad of		C	may belong to either of the major scales of		C, G, or F.
Minor	,,	D	,,	,,	C, F, or B♭.
Minor	,,	E	,,	,,	C, G, or D.
Major	,,	F	,,	,,	C, F, or B♭.
Major	,,	G	,,	,,	C, G, or D.
Minor	,,	A	,,	,,	C, F, or G.

But this is not so with the diminished triad. The series of notes forming that chord *can* only belong to one scale, namely, that of C major, or its relative A minor; and,

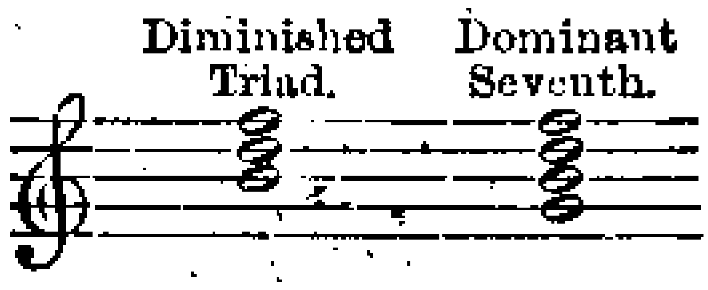
therefore, the moment we see or hear it we at once identify the scale to which it belongs. This gives it a great importance in modern music, where the *tonality* is such an indispensable element.

In spite of the nominal dissonance of this chord, it can hardly be said to be disagreeable to modern ears; on the contrary, it is one of those most highly appreciated in modern music. But it was a long time before it got into use. The early harmonists had the greatest abhorrence of the dissonant interval it contains. According to Guido's hexachords, there was no syllable for the seventh, B, and it was considered to belong to another hexachord, that of G, and was called *Mi.* Hence, retaining the proper denomination of the F, namely, *Fa*, the combination B—F was called *Mi contra Fa*, and the opinion about it was expressed in the proverb, "*Mi contra Fa diabolus est!*"

It was only in the seventeenth century that the boldness of Monteverde established, against enormous opposition, the use of the dominant seventh, of which this diminished triad is the essence. And now this chord is become one of the most common and essential in modern music. These singular changes of taste afford the best possible proof that the feelings which give rise to them are much more governed by æsthetic or psychological considerations than by any natural necessity.

The Dominant Seventh.

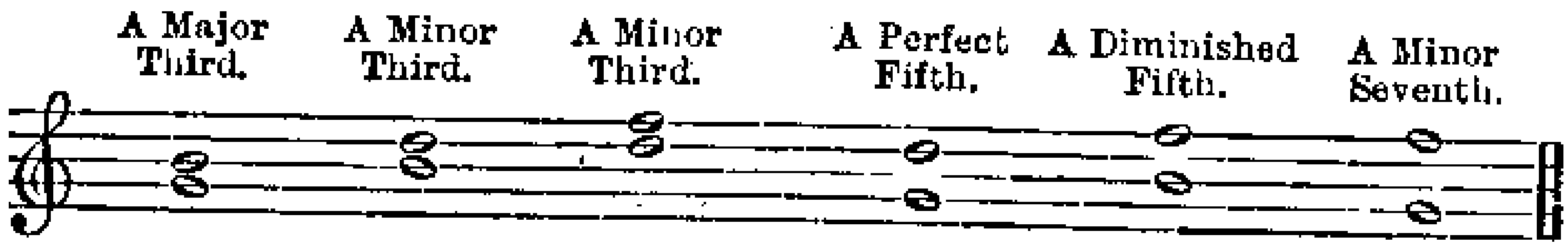
It is a very easy step from the diminished triad to the chord called the *Dominant Seventh.*



It is formed by adding a fourth note, a major third below the lowest note of the diminished triad. Or, which amounts to the same thing, we may begin with the major

triad on the dominant, and add a fourth note, a minor third above it, thus—

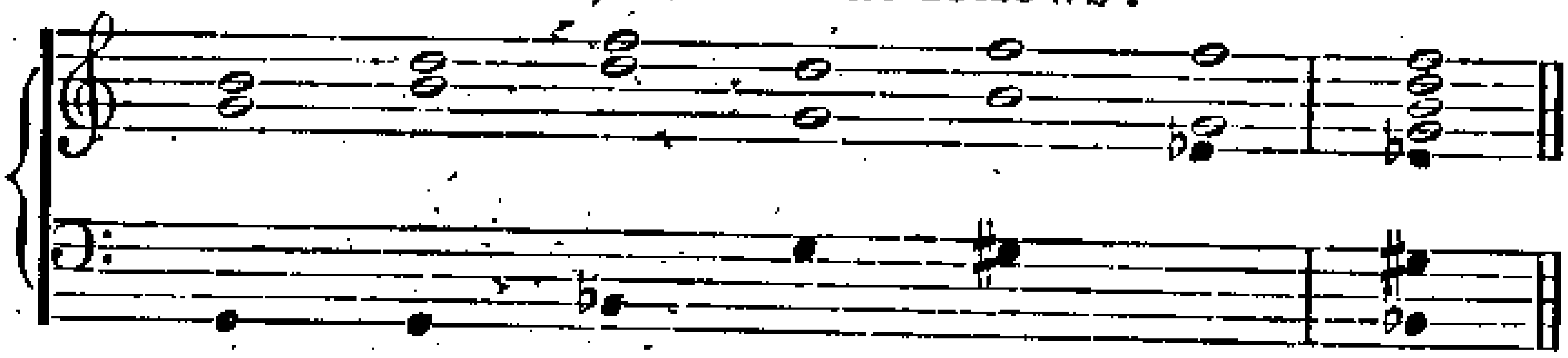
In this chord, which consists of four notes, we get six binary elementary combinations—



And the numerical values of these are—

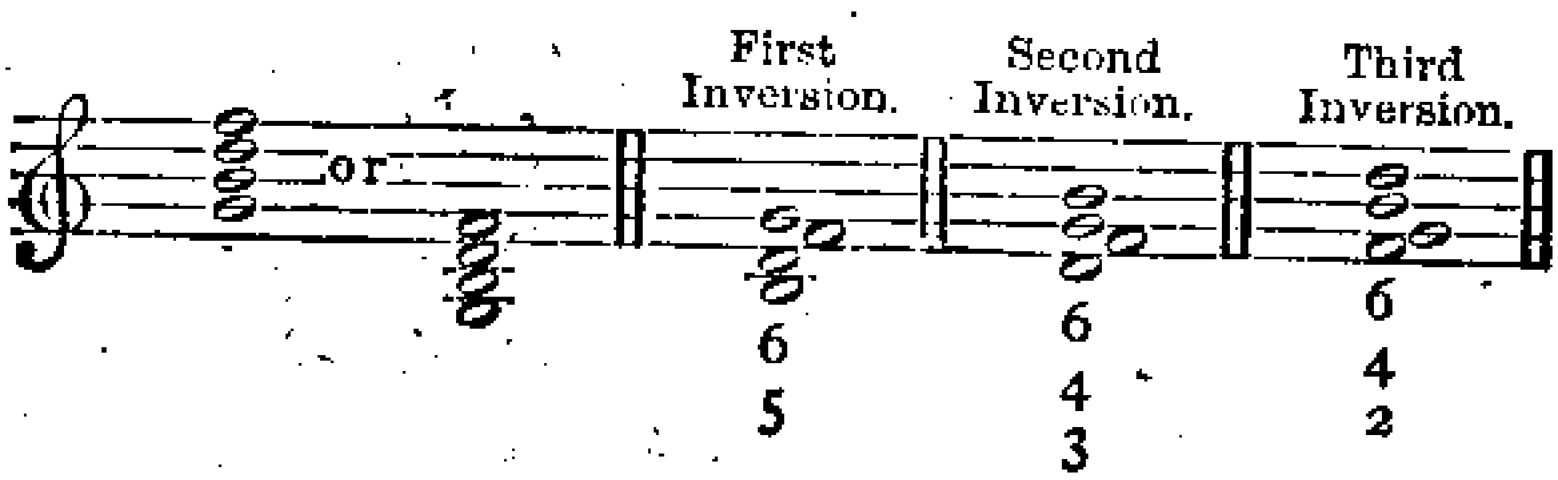
Major third	8
Minor third	20
Minor third	20
Perfect fifth	0
Diminished fifth	28
Minor seventh	23
Degree of dissonance of the dominant seventh in this position	99

The two latter are dissonant combinations, and hence the chord, as a whole, is classed as a discord. Testing by the Tartini harmonics, we find as follows :—



where the B♭, G♯, and E♭ are inharmonious.

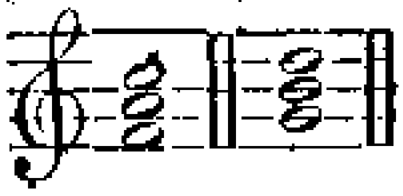
The chord may be taken in different positions, and it admits of three inversions by taking different notes in the bass, thus—



These variations change the dissonant combinations. The minor seventh, by inversion, becomes a major second; and the diminished fifth becomes a tritone. The dissonant values, in the inverted positions, are given in the table.

As the dominant seventh contains the diminished triad we have just been considering, it also possesses the same property of defining the key of the passage in which it occurs.

It is often supposed that the term *dominant seventh*, means that this chord somehow *commands* the chord of the tonic to be heard after it. This is a misapprehension. The fifth of the scale was, long before this chord was known, called the *dominant*, from its frequently *predominating* in the melodies formed on that scale. Hence, the dominant seventh merely means the chord of the seventh on this dominant note, without any metaphorical signification.

Theorists have, of course, tried to invent hypotheses as to how this chord is derived. Rameau was one of the earliest, and his explanation is very ingenious. He first points out that the two major triads of the dominant and subdominant suffice to define any key. For example, these two chords  cannot both exist in any major scale except that of C.

He then says that the object of the dominant seventh is to add a part of the chord of F to the chord of G, in order to combine, to a certain extent, both chords in one, and so to get one chord which will of itself define the key.

Rameau, however, does not attempt to assert that this chord is a natural one; he expressly says it is "un ouvrage de l'art"—although, for some reason he does not clearly explain, he considers it "indiquée en quelque manière par la nature."

Helmholtz takes another view. It will be seen that in

the series of natural harmonic sounds or partial tones on page 40, the seventh is set apart as not belonging strictly to the ordinary musical scale. Taking C as the fundamental, it is marked as B♭, but it is really somewhat flatter than the proper note of this name. The ordinary interval of the minor seventh has the ratio 9 : 5, log. = 255; while if the seventh partial tone be substituted it has the ratio 7 : 4, log. = 243—the difference between them being about half a mean semitone; or, in other words, the seventh partial tone, or *harmonic seventh,* as it is called, lies half-way between A and B♭. If we include this note, and form a compound tone with the first seven partial tones, we get the following combination  which corresponds in appearance with the chord we are now considering.

Now Helmholtz thinks that, the natural or harmonic seventh being so near to the ordinary minor seventh, the chord containing the latter "may be very well regarded as a representative of that compound tone." And he considers this may be the reason why the chord of the dominant seventh is set free from many obligations in the progression of parts to which dissonant sevenths are otherwise subjected, as, for example, being used without preparation. Of course, under this explanation, the chord of the dominant seventh may be said to have a natural root, being a representative, though an imperfect one, of a compound sound.

But, it must be observed, he puts this view somewhat doubtfully, and it is open to considerable difficulty, which hardly seems to have been fully allowed for.

It must be admitted that the harmonic seventh makes an agreeable combination with its fundamental, though the effect is new to our ears. But this natural seventh is not

the note that is actually used in the chord we are speaking of. This note must belong to the ordinary scale, and must, by the essential construction of the chord, be *a minor third above the fifth.* And if voices were singing the full chord, the substitution of the harmonic seventh, half a semitone flat, would not do at all; it would be unsingable.

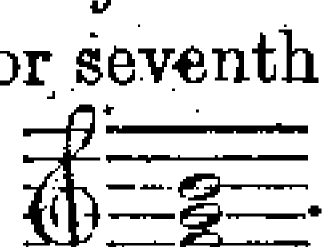
Again, there is this consideration, that if the dominant seventh represents the compound sound, it ought by nature to be a concord, as complete and satisfactory in itself as the major triad, which is quite contrary to the usual understanding.

It would seem, therefore, that Helmholtz's explanation merely means that there is a natural combination of notes *something like* the combination called the dominant seventh, and does not go farther.

There are some other varieties of chords of the seventh; and although it is not our business here to give an elucidation of all the details of practical harmony, some of them may be briefly alluded to, in order to show how they are affected by theoretical considerations.

In all cases we shall consider the normal position of the chord to be that in which its notes are arranged in thirds. It will not be necessary, except in some special instances, to give the binary combinations of which the chords are made up; it will suffice to refer to the table for the deduced dissonant values.

Major Triad, with a Major Seventh.

We may have a major seventh added to the major triad of the key-note, thus— . This may have three inversions—  all used.

The chord contains one dissonant binary element, the major seventh, which in the inversions becomes a minor second.

We have already mentioned, on page 231, a principle of deriving chords often resorted to,—namely, by searching for them in the natural scale of partial tones, in extension of the original system of Rameau. He found that the major triad was contained in the six first partials, and inferred, soundly and correctly enough, that this fact proved the natural origin of the chord. Some theorists have attempted to carry this farther, fancying that it ought somehow to apply to harmony generally.

The chord we are now considering offers an example, for referring to the table of partial tones on page 40, it will be seen that the eighth, tenth, twelfth, and fifteenth sounds correspond with the notes of the chord, which would be cited as a "natural derivation" and warrant for this harmonic combination.

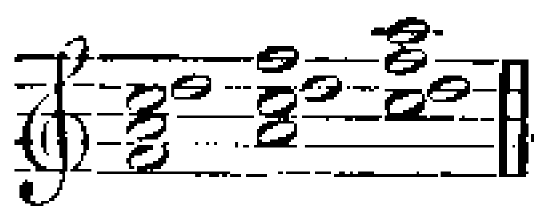
Nothing can be said against this fact; but the principle, that harmonic combinations generally are to be considered as derived from, or justified by, the existence of their notes in the series of partial tones, cannot be a sound one. In Rameau's original case the few lower partial tones are prominently audible, and their bearing on the popularity in music of the major triad cannot be gainsaid. But when we get among the higher harmonics, the case is altogether changed. Their tones are not prominent; they can only be heard by an effort, and often not at all. We know them chiefly by theory; and the idea that they could ever practically give rise to harmonic combinations is pure imagination.

Besides, the principle that combinations of harmony are derived from the series of partial tones, would prove too little on the one hand and too much on the other. It would prove too little, because there are some chords in undisputed use that cannot be so derived, there being no partial tones to correspond with them; and it would prove too much, because, if carried far enough, it would sanction combinations that are not only unused, but altogether unusable. The theorist must pick out of the series

only such sounds as suit his own purpose; which is, of course, giving up the principle as a logical system.

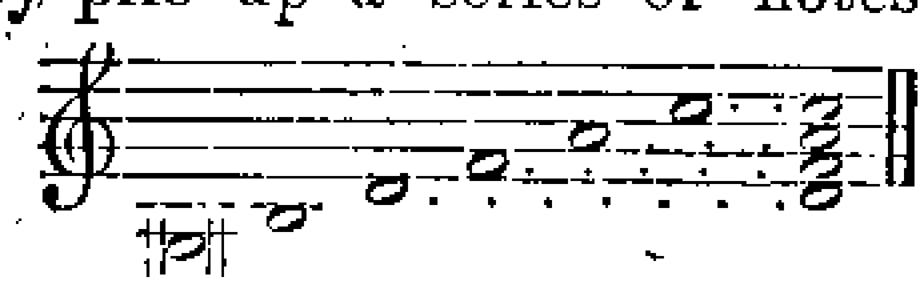
On Rameau's plan of combinations, this chord may be considered as formed by the major triad of C, combined with a portion of the major triad of G.

Chord of the Seventh, on the Second of the Scale.

We may next take a chord of the seventh, which is formed naturally on the second note of the major scale, thus—  It admits of three inversions all very frequently used—  The first of these is a very important one: it is the major triad of F, with a sixth added, and hence it has been given the name of the "added sixth." Rameau calls it the "great sixth."

The chord has one dissonant binary element, the minor seventh, which in the inversions becomes a major second.

There has been an enormous amount of disputing about the "derivation" of this chord. Some theorists consider what is here called the first inversion to be the normal form, and call the root F. Others, adhering to the original form, call the root D. But it is clear neither F nor D, used as a *générateur*, will contain among its harmonics all the notes of the chord.

Some musicians take another view. From the fact that the natural triad happens, in its normal position, to consist of two thirds superposed, they assume that this is the natural way of deriving chords generally. To adapt the theory to the present case, they further assume a fundamental note G, on which they pile up a series of notes at intervals of thirds, thus— 

and then, selecting from the series the four upper

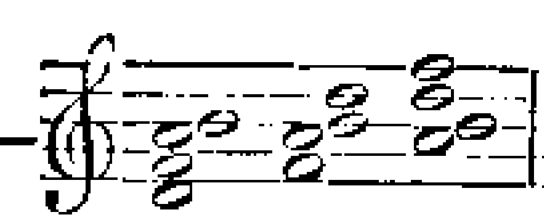
notes which form this chord, they call its root G. But on this principle, why not select the *three* upper notes, forming the major triad of F, and insist that this also is derived from the root G?

It is reasonable and useful to write a chord in thirds as its simplest position, but this can convey no idea as to its origin or derivation.

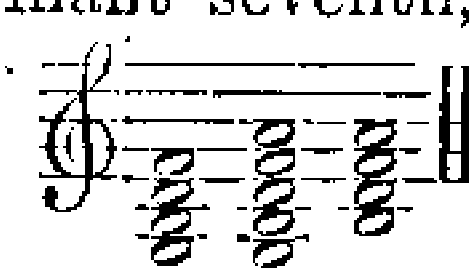
Rameau, who attached importance to this chord, considered it (like the dominant seventh) a combination of the subdominant and dominant natural harmonies.

Diminished Triad, with a Minor Seventh.

We may add a seventh to the diminished triad, thus—  which gives a discord in very frequent use.

It has three inversions, all well known— 

There are two dissonant binary elements, the diminished fifth and the minor seventh, which, when inverted, become the tritone and major second respectively.

It is very common to assume this chord to be formed by adding a *ninth* above the dominant seventh, and then omitting the lower note; thus—  Indeed, it is sometimes called the *Dominant Ninth* for this reason. Richter (p. 65) speaks of this assumption as an invention of the older harmonists, which is unnecessary and far-fetched; and adds that it is much preferable, for practical purposes, to make all explanations as simple as possible,—a very praiseworthy opinion.

If any other explanation is wanted than the simple list of the notes, it may be called, on Rameau's principle, a combination of portions of the dominant and subdominant triads.

Chromatic Chords.

The chords above-mentioned may all be formed from the notes of the ordinary diatonic scale; but the list may be considerably extended by the introduction of *chromatic notes,* which will give rise to some harmonic combinations very effective in modern music.

Diminished Seventh.

In the foregoing chord, if, instead of a major third for the upper interval, we put a *minor* third, thus— 

we get the useful modern chord of the *diminished seventh.*

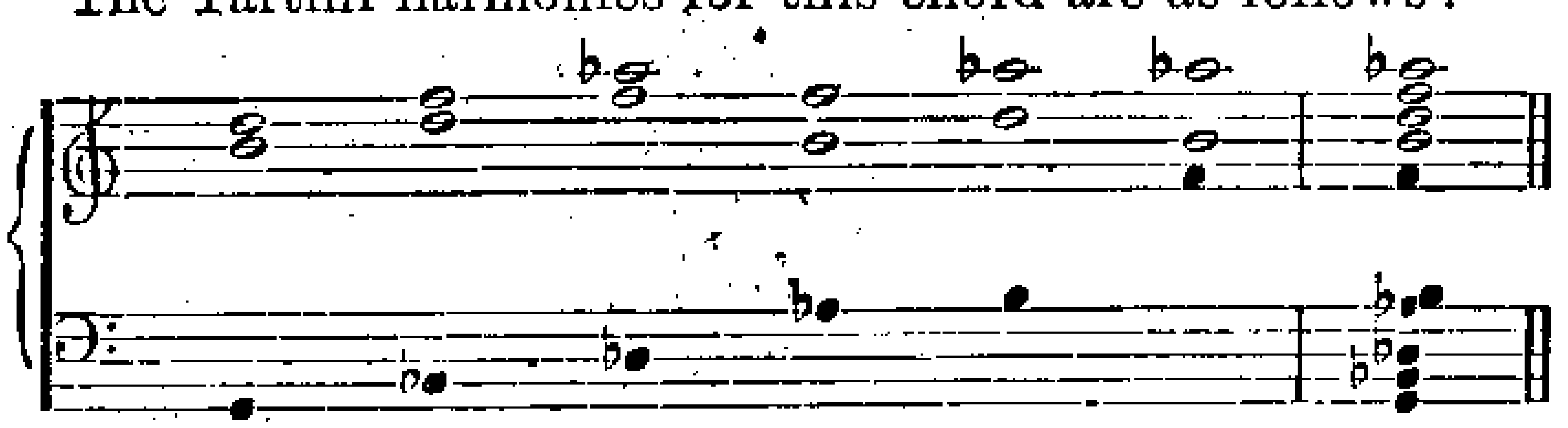
It is worth while investigating this a little more closely. It consists of six binary combinations—

A minor third, B to D,	20
A minor third, D to F,	20
A minor third, F to A♭,	20
An imperfect fifth, B to F,	28
An imperfect fifth, D to A♭,	28
A diminished seventh, B to A♭,	24
Degree of dissonance	140

i.e., three minor thirds one above the other, two imperfect fifths interlaced, and a diminished seventh.

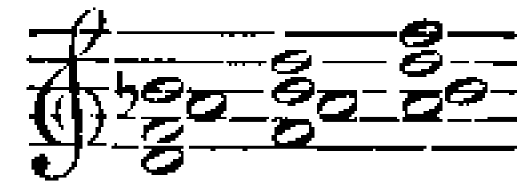
It contains no perfect fifth or major third; and its three dissonant binary combinations ought, theoretically, to render it very harsh.

The Tartini harmonics for this chord are as follows :—



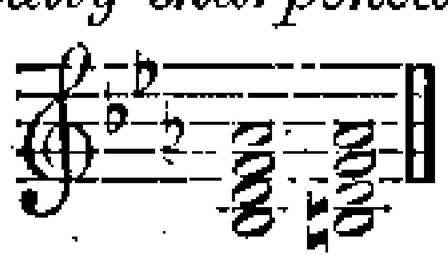
i.e., three out of the six grave harmonics are discordant with the main notes of the chord, thereby adding to the

dissonant effect. But in practice it is one of the most popular chords of modern music—such is the influence of habit and education on our impressions.

It may take three inversions,  all equally useful. In these one of the minor thirds becomes a major sixth, the diminished fifth becomes a tritone, and the diminished seventh an augmented second.

On an equally-tempered instrument the construction of the chord is very simple and symmetrical, being the same in all positions; and it admits of enharmonic changes of great convenience in modern harmony.

This chord is "accounted for" by theorists in two different ways. One class derive it from the major triad of G, with the minor seventh and minor ninth added, and the root omitted; in reference to which one may merely remark, with Richter, that such an explanation is unnecessary and far-fetched, and regret that so much ingenuity should be wasted for no good end. Another class derive it from quite a different source, namely, from the dominant seventh in the key of E♭, but having, as they express it, the root B♭ "*chromatically sharpened,*" thus—



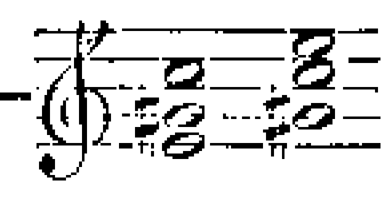
But this explanation involves the curious misconception of the nature of chromatic notes, mentioned on page 140. To consider B♮ as "B♭ sharpened" is a gratuitous and unfounded assumption. B♮ is altogether a new and independent note, having no relation to B♭ at all, beyond the accidental circumstance that, from the scantiness and imperfection of our notation, it happens to occupy the same position in the stave. If this principle were true, it would only be necessary to screw up the B♭ a little more, making it C, or D, to prove that C and D were only "B♭ sharpened," which would be absurd. B♮ is a note as

completely independent of B♭ as C and D are. Hence the explanation merely asserts that the note B♭ is removed, and a new note is put in its place, which is obviously no explanation at all.

If we are to seek any derivation of the chord, it may most reasonably be found on Rameau's plan, by considering it to be a combination of two diminished triads, one on the leading note of the scale of C, the other on the leading note of the scale of E♭, thus—

Augmented Triad.

We have seen that the diminished triad is formed of two minor thirds. There is another analogous triad, formed of two *major* thirds, thus—  It is called the *augmented triad.* It contains one dissonant binary element, that of the augmented fifth.

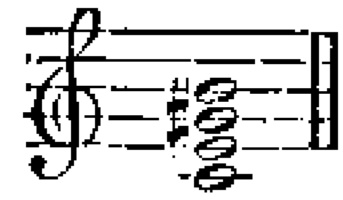
It admits of two inversions, both much used— 

In these the augmented fifth becomes a diminished fourth, and one of the major thirds a minor sixth. On an equally-tempered instrument the chord is the same in all positions.

Some theorists consider this chord as a mere variation of the major triad by "sharpening" the fifth; but the fallacy of this idea has already been pointed out, the G♯ being not "G sharpened," but a distinct and independent note. On Rameau's principle, it may be said to be a part of the major triad of C, combined with a part of the major triad of E.

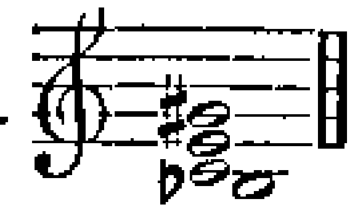
Augmented Triad, with a Major Seventh.

In the same manner as we have added sevenths to the major triad, the minor triad, and the diminished triad, so we may add sevenths to the augmented triad.

First, the major seventh—  This also, on Rameau's plan, would be a combination of the major triads of C and E.

Augmented Triad, with a Minor Seventh.

Or we may add the minor seventh thus— 

As, however, in this position, the G♯ and B♭ clash very awkwardly, it is more customary to use it in one of its inversions; thus— 

This is a very powerful chord; it was used by Mozart, and is a great favourite with modern writers, M. Gounod especially.

Augmented Sixth.

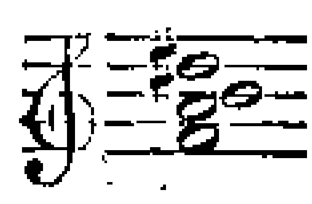
Another chord of the greatest power in modern music, and by means of which the finest effects have been obtained, is that known as the Augmented, or extreme sharp, Sixth. This chord is of complex structure, and requires careful explanation.

The principal element of the chord is the binary combination from which it takes its name. To this, however, have to be added other notes, which may be varied in different ways, forming different varieties of the general chord, each variety having a special name.

1. *The Italian Augmented Sixth.*

This, made by adding a major third to the lower note of the characteristic interval, is the simplest and most elegant form.

2. *The French Augmented Sixth.*



This is formed by adding a second major third below the upper note.

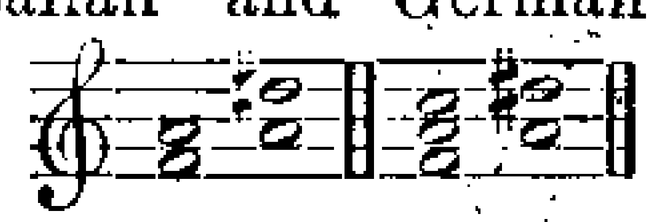
3. *The German Augmented Sixth.*

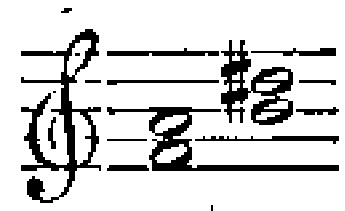
This is formed by giving the complete major triad on the lower note, and adding the augmented sixth above it. On an equally-tempered instrument it consists of exactly the same notes as the dominant seventh on F; but, of course, when the notes are correctly given, the D♯ is different from the E♭.

There is a fourth form, namely—  but this has been already considered as a modification of the augmented triad.

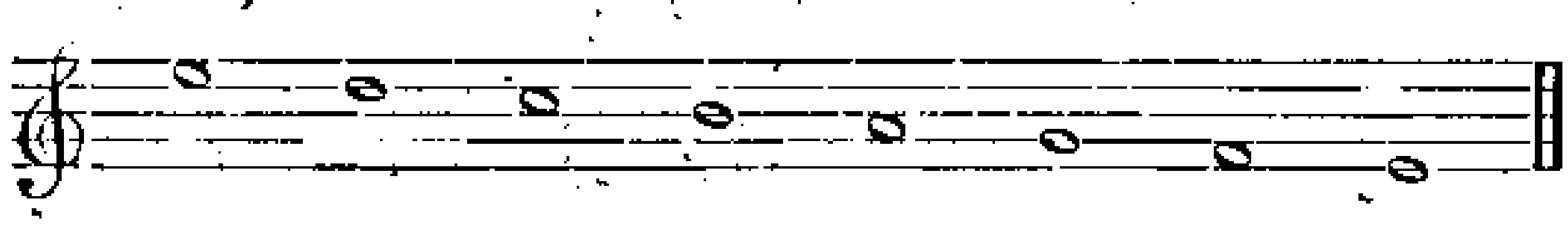
The chord of the augmented sixth has given rise to several so-called explanations and derivations; but they all generally involve the "accidental sharpening," or "accidental flattening," of some note, which we have already objected to.

Rameau's principle of explaining chords by combination might very well be applied here.

The Italian and German forms on this principle would be  *i.e.*, each a combination of part of the major triad of F with part of the diminished triad on D♯.

The French form would be  a combination of parts of the major triads of F and B respectively.

Helmholtz gives an ingenious explanation by detecting in this chord a remnant of one of the old Greek modes, the Dorian,—



and he says the interval of the augmented sixth, taken

in conjunction with its usual resolution, suggests a combination of the Dorian descending cadence with our modern ascending one, in the same key, thus:—

There are other combinations of dissonant harmonies; indeed, almost any combination of notes may be used by bold and clever composers. As, however, the object here is not to give a complete treatise on harmony, we need not go further into them.

The following table exhibits the comparative degree of dissonance of all the chords mentioned above, calculated for their different positions in the manner already explained. It does not, however, take into account the effect of the combination-tones.

COMPARATIVE DISSONANCE OF CHORDS.

The normal position is, in all cases except the augmented sixth, the position where the notes lie in thirds above each other.

	Normal Position.	Inversions.			Mean.
CONCORDS.					
Major Triad	28	42	13		28
Minor Triad	28	13	42		28
DISCORDS—THREE NOTES.					
Diminished Triad	68	43	43		51
Augmented Triad	55	53	53		53
Italian Augmented Sixth					43
DISCORDS—FOUR NOTES.					
Dominant Seventh	99	122	85	83	97
Major Triad with Major Seventh	78	120	93	120	103
Seventh on Supertonic	71	65	96	65	74
Seventh on Leading Note	99	83	85	122	97
Diminished Seventh	140	115	107	115	119
Augmented Triad with Major Seventh	...	...	...	...	117
,, ,, Minor Seventh	...	...	...	...	123
French Augmented Sixth	...	...	...	...	103
German Augmented Sixth	...	...	...	...	87

Accidental Dissonant Notes.

The chords we have been considering are all legitimate, substantive, and independent combinations, consisting of notes that must be studied in their proper bearings one to another.

But there are dissonant harmonies of another kind, very common in modern music, which are due to the introduction accidentally of dissonant notes, forming no part of any legitimate substantive chord.

As in all other matters connected with harmony, these dissonances have given rise to many theories and discussions. When, however, we look at them from a philosophical point of view, we find them by no means difficult of explanation, or requiring any recondite harmonical hypotheses.

Their use depends on an æsthetical principle, which is perfectly well established in analogous cases, and which can easily be shown to be also applicable here. This principle is the same that has been described, for another object, on page 43, namely, that the senses are inclined, in the presence of impressions which are *specially prominent*, to overlook others which are less so. Everybody knows, for example, how a certain bright colour will "kill" (as the expression forcibly puts it) others which, if presented alone, would make perhaps a strong impression. And we may find an abundance of instances, in all sorts of transactions of everyday life, where, if the mind is actively directed to one thing in particular, other things present are almost entirely disregarded.

Now, in modern music there are a great many things offered to the attention of the mind. The whole composition is made up of several different elements. There is motion in pitch and motion in time, both offering all sorts of attractive melodial variety; there are harmonic effects, contrapuntal effects, effects of varieties of tone

and so on. The listener has to observe and appreciate all these; and experience shows that if special interest be offered in any particular direction, the mind insensibly attaches predominant importance to that, and will pay far less attention to others.

It is a legitimate application of this principle that the ear will tolerate temporary dissonances without displeasure, if they occur at the time when some interest of another kind is offered to the mind; and, under this condition, it matters little what the dissonances are, or what relations they bear to the consonant parts of the harmony.

Some examples will explain this much better than it can be done in words; and we may specify several modes of application of the principle in question, all well established in practical music.

The most common mode of introducing accidental dissonant notes is as a consequence of *melodial motion.* If a florid melody be played or sung, and accompanied by simple harmonies slower in change than the notes of the melody itself (which is usually the case), then the melody will probably introduce a great number of dissonant notes that clash with the harmony.

But as the mind is pleasurably occupied by observing the melody, it allows these dissonances to pass without receiving from them any disagreeable effect. For example—

Here the notes marked * are dissonant with the harmony; they are usually called *passing notes,* and practical rules are made for their application. Professor Macfarren

says ("Lectures on Harmony," page 59):—"Were it not for the employment of passing notes, all music would have the gravity of psalm tunes; all lightness, all grace, all freedom in melody result from a judicious use of passing notes. This was the earliest deviation from the primitive form of plain or simple counterpoint in note against note, and its introduction is ascribed to John of Dunstable, who lived in the first half of the fifteenth century."

The principle of the existence of these passing notes is clearly the æsthetic one above-named. The dissonances are there, but the mind refuses to notice them, being occupied with the more prominent attraction of the melodial movement.

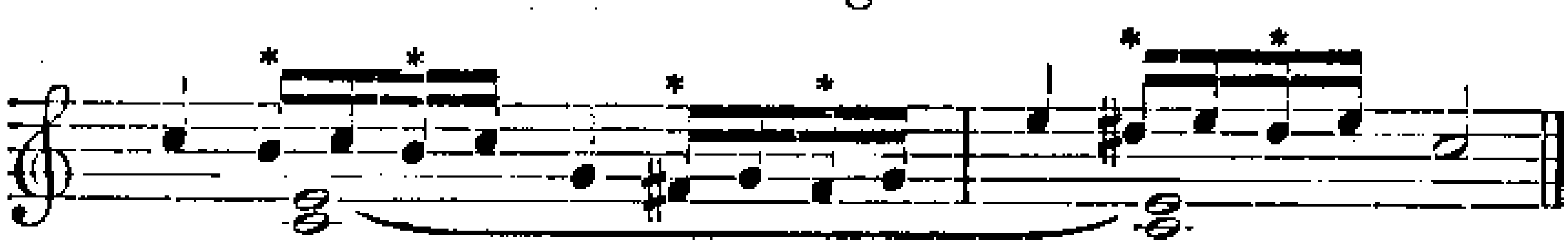
This sort of dissonance occurs very frequently and prominently in music of many parts. The ear and the mind become so interested in the progress of the different parts of the composition, that they readily overlook dissonant harmonies which are brought about by the melodic progressions, particularly if these progressions are in themselves striking and effective. The following example is from a madrigal by Luca Marenzio, 1580:—

And it is worthy of observation that this was the way that discords first came into use. For counterpoint furnished the first harmony, and at a very early period the discords arising from the progressions of the parts were allowed to

pass as a necessary consequence of the construction of the music.

Richter fully admits this principle; for he says emphatically, that a good "Stimmführung" (*i.e.*, good writing as regards the melody of contrapuntal parts) will cover a multitude of effects in harmony which would be otherwise sins.

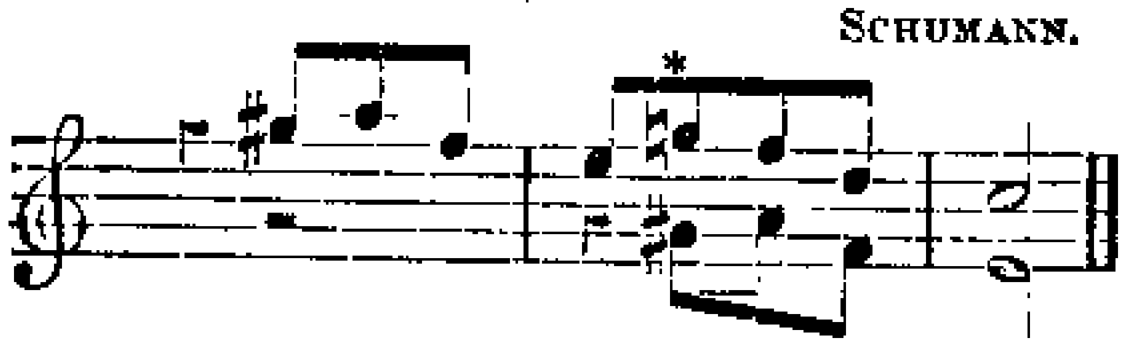
Dissonances will naturally result from the *ornamentation* of melodial passages, by appogiaturas or otherwise, as in such cases as the following:—



The dissonances in the following examples, although sometimes very harsh, are concealed by the interest of the melodial motion:—

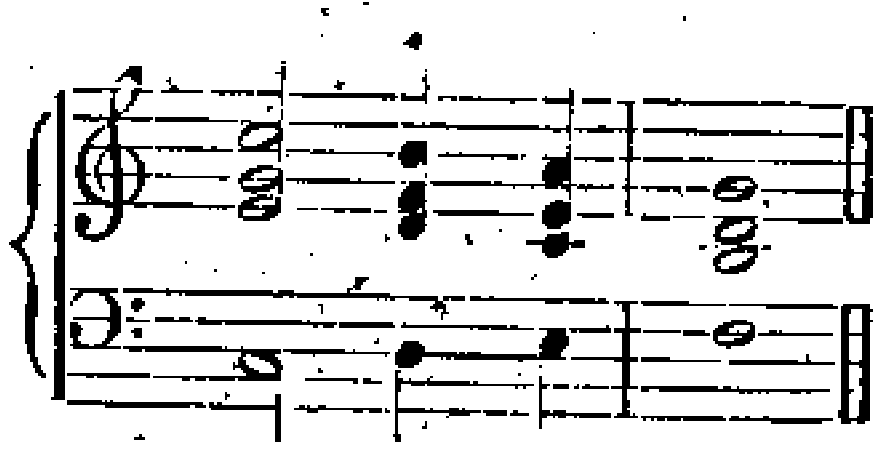
HAYDN.

SCHUMANN.



SCHUMANN.

MOZART.



In the following passage, from one of the most melodious of Mozart's airs,—

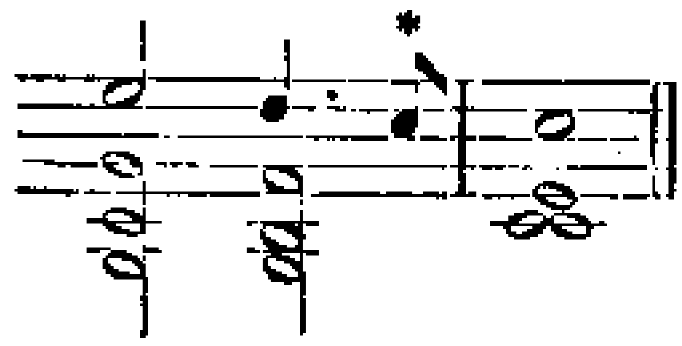
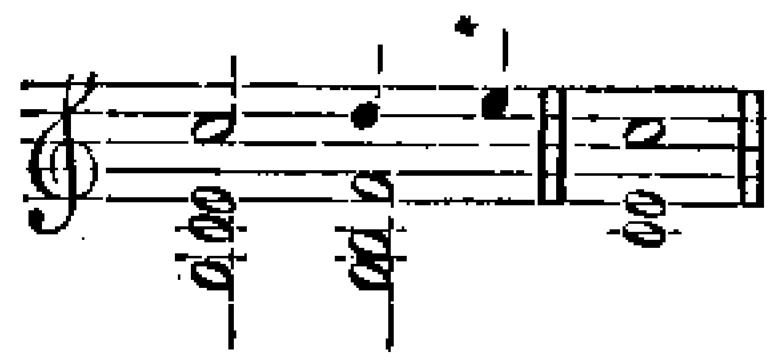
the notes, E, F♯, G♯, A, B, are all sounded together on the accented part of the bar; and yet so beautiful are the melodial features that no one ever notices any harshness in the effect.

Another and very common mode by which dissonances are accidentally introduced, is by causing a note belonging to one harmony to be *suspended* into a following one, thus—  Here the mind is occupied and gratified by the device of the suspension, and so overlooks the dissonance in the harmony.

The following are examples of a more dissonant effect:—

Dissonant notes may also be introduced in the contrary

way, namely, by what is called *anticipation, i.e.*, by allowing an element of a harmony to enter on one which precedes it; for example, it is very common at the close of a piece to anticipate the final chord before its time, thus—

 or 

In all such cases the ear, attracted by the melodial effect, quite ignores the dissonance.

Accidental dissonances may further be introduced by a long holding note, called a *Pedal note*. For example—

MOZART.

The origin of this is that an organist, holding on the bass note by a pedal key (whence the name), would play a series of changing harmonies above it, and the mind, impressed by the striking feature of the holding note, would ignore all the dissonances brought about by it.

The pedal note has, however, been extended far be-

yond its original meaning, as, in modern music, it is common to introduce long holding notes, foreign to the changing harmonies, in any position. Beethoven, for example, has, in the slow movement of his symphony in C minor, passages where an upper E♭ is sustained against the harmonies of A♭, D♭, and B♭ successively, with melodial figures, in the lower parts; and many other similar examples of holding notes, both in the upper and the middle parts, may be found.

M. Gounod has, in one of his songs, this fine passage—

Here the intrusion of the G♯ into the second bar, where as a matter of harmony it is quite out of place, is the result of its being sustained as a "pedal note" in the inner part. If it should be argued that the harmony of the second bar may be considered the minor triad of C♯, including the G♯, then we have the feature of the melodial march of the bass through A and A♯, both foreign notes, which is still only another example of the same æsthetical principle of covering dissonance by prominent features of unusual attraction.

Sometimes two pedal notes, usually a fifth apart, are sustained together.

In the following passage, the chord at * contains every note of the scale, all seven sounding simultaneously and *sforzando*, and yet the effect is quite tolerable; the mind seizes on the fact that the upper two notes are suspensions, and the lower one a "pedal note," and so the interest

of these covers the strong set of dissonances, which, presented heterogeneously, would be unendurable:—

It is a curious example of what loose statements will pass for reasoning in musical matters, that it is often thought sufficient, in order to account for the tolerance of these accidental discords, simply to name the mode in which they occur. Thus we hear it said that discords are allowable *because* they occur in passing notes, or in appogiaturas, or in pedal passages, &c. Or if any further explanation seems wanted, it is added that nature approves of them in such places,—just as the old philosophers declared that "nature abhorred a vacuum." The question *why* discords should be more tolerable in such places than in plain chords, seems never to have presented itself, and yet the answer is so simple!

CHAPTER XIX.

HARMONY CONTINUED.

D.—Harmonic Progressions.

In the last chapters we have been considering the simultaneous combinations of notes used in our modern music. But there is another and very essential part of harmonic doctrine to be taken into consideration, *i.e., The nature of the progressions from one combination of notes to another.*

This is quite a distinct matter from the former; and we know, by the commonest experience, that the contrasts arising from these progressions influence our musical sensations in a most important degree. In fact, it is by the progression of harmonies that fine music is distinguished as much as by any other feature. For this reason, writers on harmony consider it as essential to give rules for harmonic progressions as for harmonic combinations of notes; and it is our business, therefore, here to inquire what grounds or justifications there are, on natural and philosophical principles, for such rules.

The question to be considered and answered is, May we proceed freely from any combination of notes directly to any other combination? If not, why?—and what are the principles that should guide our progressions?

There would appear to be only one reason why we may not, after any chord, proceed to any other chord we please,

namely, that the new combination of notes should have some sort of *relation* to the preceding combination.

This is not simply an arbitrary musical idea; if it were, we should be falling into the error we have so often striven to avoid and to correct, *i.e.*, reasoning *ex post facto*, by what is, instead of what ought to be. It is a rule existing in many other cases that the sequence of ideas must be connected and logical, and that abrupt transitions are, as a rule, to be avoided. In literary composition this is especially so: the mind expects that, unless a positive and intentional break intervenes, what follows shall have a relation to what precedes; and the harmonic principle of progression is only an adaptation of the mental requirement here involved.

It does not follow that these relations in harmony should always be fully preserved; they may be relaxed, or occasionally, at the pleasure of the composer, dispensed with altogether. In the analogous cases we are often pleased, rather than offended, by startling and unexpected contrasts judiciously contrived. But the exceptions only prove the rule—that the mind, in the ordinary course of things, prefers that in harmonic, like other progressions, some definite and logical relations should be preserved.

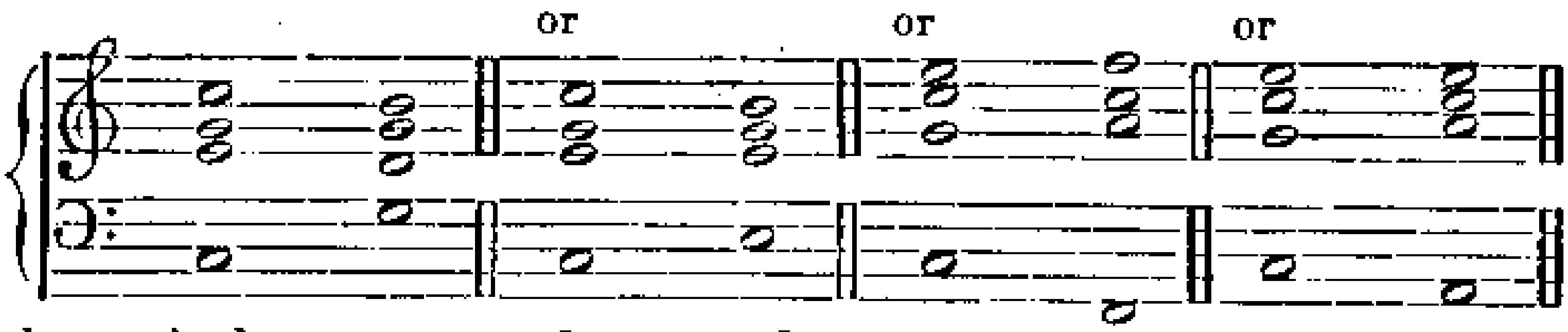
We have, therefore, now to inquire what these relations are, which one combination of notes may bear to another in juxtaposition.

Chords may be related to each other in several ways.

In modern music the simplest and most obvious relation is, that they shall have the *same tonality, i.e.*, that the notes of which juxtaposed chords consist *shall belong to the same key and the same diatonic scale.*

It has been pointed out, in the last chapter, that several different concords may be formed on the various notes of any diatonic scale, and these all bear to each other the relation in question. Hence (omitting for the present the case of discords, which will have special consideration

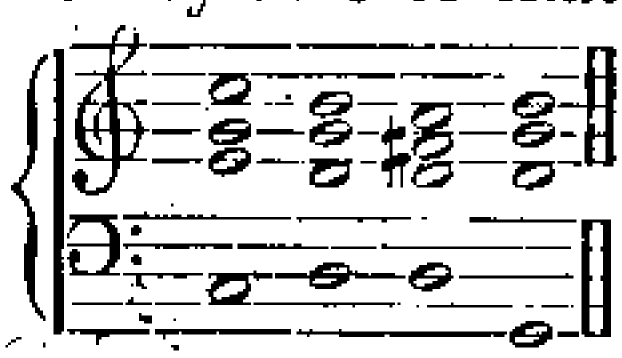
hereafter), if we pass from any concord to any other belonging to the same key, thus—



the mind accustomed to modern music recognises a relation which warrants the transition.

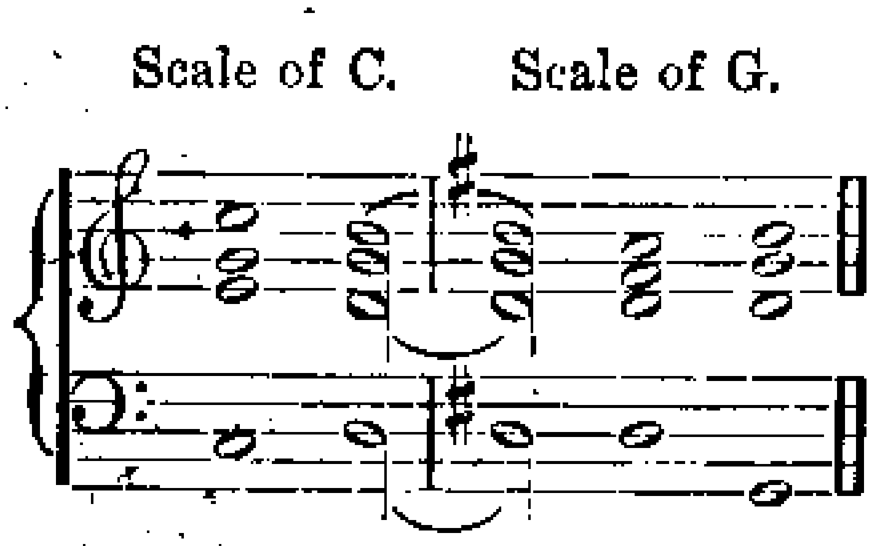
The violation, however, of this relation is exceedingly common, producing what is called *modulation, i.e.*, passing from a chord in one scale into a chord belonging to a new one. There are many ways of doing this, which are explained in practical works. It will suffice here to illustrate the most simple way, as it involves a curious principle, namely, the essential preservation of the principle of tonal relation while making the change.

Thus, take one of the simplest and most elementary modulations, from the key of C to that of G—



Here at the third chord we take a combination which is not in the scale, and thus appear to violate the tonal relation.

But the real theoretical interpretation of the passage is as follows :—

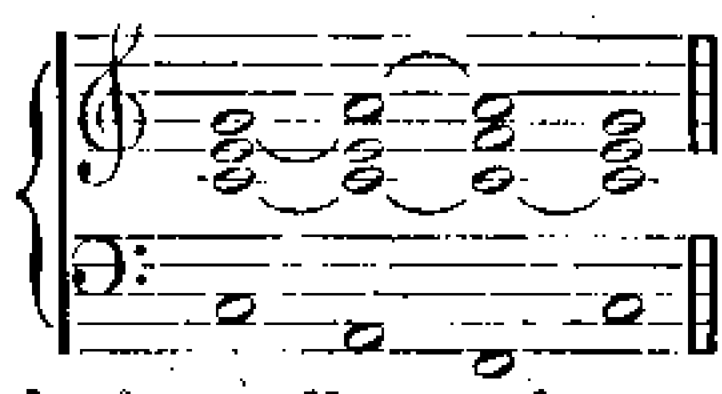


That is, when we are on the chord of G, we get what is called an equivocal chord, which belongs both to the scale of C and that of G. While, therefore, we are on this note, we suppose the scale to be *suddenly changed;* and this

enables us to pass to the new chord, keeping up the tonal relation between the two. This is the principle of most of the simpler varieties of modulation, and a very ingenious one it is.

At the same time, it must be admitted, that in modern music the devices of modulation are often so abrupt and eccentric that it is difficult to reduce them to any rule; and in these cases we can only fall back on the general principle, that the departure from the tonal relation is addressed to the mind as an exceptional and abnormal stimulus from which, if judiciously contrived, more æsthetic pleasure may be given than by an adherence to the more ordinary routine.

Another kind of relation between chords is their having *one or more notes common to both*, thus—



This clearly and naturally tends to render *smooth* to the ear the passage from one chord to another. It is accordingly often insisted on in the rules for the stricter kinds of composition, although by no means an imperative condition in music generally.

Then there is another relation of a more recondite and hidden character; consecutive chords may be related to each other through the means of *compound harmonic combinations.*

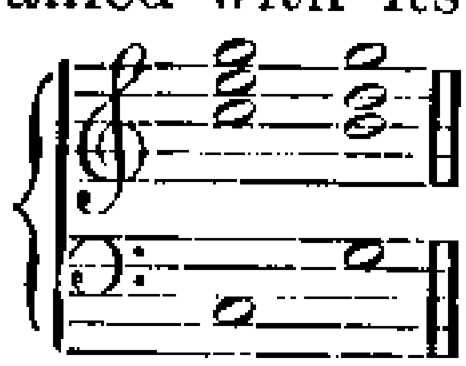
This was one of the harmonic rules devised by Rameau, and it was the foundation of his famous invention of "Basses fondamentales," which, from the singularly philosophical and happy explanation it affords of some of the most important relations of harmony, it is necessary here to explain.

In giving rules for the progressions of harmony,

Rameau assumes for each chord what he calls a "Fundamental Bass," by which term he means the true generator, or root, of a natural harmony contained in the chord, as explained on page 229. Thus the chord C, E, G, however it occurs, is assumed to have the "fundamental bass" C;—E, G♯, B, has the fundamental bass E, and so on. He then lays down the proposition that it is most natural for a fundamental bass to move in particular ways; and that this motion will, consequently, determine the most natural relations between successive chords.

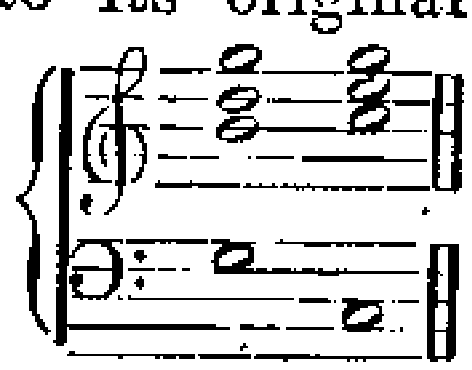
Now, the ways in which the fundamental bass may move are determined by the natural harmonics of a sounding body.

The most prominent harmonic is the *octave*, but of course this must be neglected for this purpose, as such a motion of a fundamental bass would produce no new harmony. The interval next in natural order is the *fifth*, dictated by the next in order of the series of natural sounds; and Rameau takes it for granted that the most natural motion of a fundamental bass to produce a change of chord is by an interval of a fifth. For example, suppose the bass to be sounding C, then as G is (after the octave) the first note dictated by nature from C, the progression of the bass from C to G is the most natural. Hence, as the bass is in each of these cases accompanied with its major triad, we get this harmonic progression



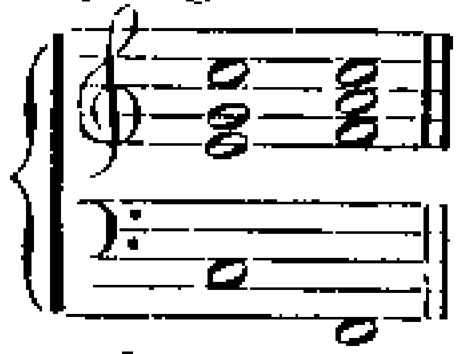
as the most natural one possible.

It is also reasonable to suppose that the bass, having risen to G, may go back again to its original place, which will give the progression

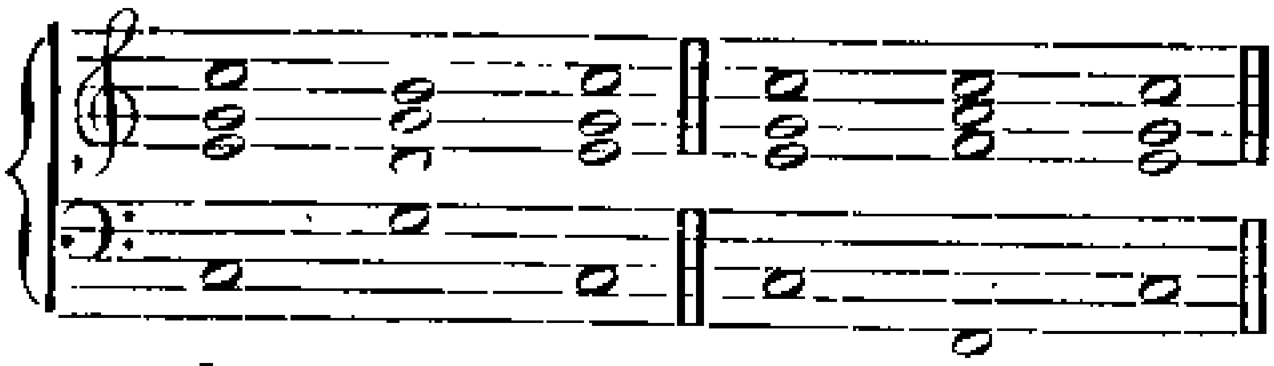


as also a natural one.

But we may apply this latter proposition in another way. The note C is the most prominent harmonic heard

(after the octave) in the natural series given by the generator F, and therefore the bass, being supposed to be on this C, may move back to F, carrying its triad with it, which gives this progression  as also a natural one, being analogous to the former examples. This may also go back to C.

Thus we arrive at these progressions as the most natural possible—



In other words, the *dominant* and the *subdominant* harmonies are those most nearly related to the tonic, in consequence of purely physical reasons.

It is unnecessary to tell any practical musician that this is justified by experience, as the fact of this intimate relationship has been one of the most prominent ever since harmony had any substantial existence, although no explanation was given of the fact before that offered by Rameau. These three chords contain between them every note of the scale; they form the foundation of the modern tonality, and are used most frequently in every piece of music, serving to impress the key on the mind, and give unity to the whole.

It is an emphatic comment on this doctrine that these relations are, in ordinary music, always used at the close of a piece. What is called a closing *cadence*, is simply the use of one of these related chords before that of the final tonic, thus—

Authentic Cadence. Plagal Cadence.

Rameau works out his plan of fundamental basses further, but it is unnecessary to follow him. What has been said is enough to show how the relations of chords, dictating their progression, may be deduced on acoustical principles from the natural partial tones of compound sounds.

The principle above arrived at will serve to explain the preference given in modern music to the particular octave-form known as the ancient Greek Lydian, and which forms our present major diatonic scale.

When harmony became popular, it was soon found, on Rameau's principle, that the harmonies of the dominant and subdominant were the next in importance to that of the key-note itself; and the Lydian mode is the *only one that makes all these three harmonies perfect major triads.* The following table shows this:—

Key-note if taken on the White Keys of Piano.	Ancient Greek Octave-Forms.	Tonic Harmony.	Dominant Harmony.	Subdominant Harmony.
C	LYDIAN .... (Modern Major)	Perfect 5th Major 3d	Perfect 5th Major 3d	Perfect 5th Major 3d
D	PHRYGIAN .... (1st Church Mode)	Perfect 5th Minor 3d	Perfect 5th Minor 3d	Perfect 5th Major 3d
E	DORIAN .... (3d Church Mode)	Perfect 5th Minor 3d	Imperfect 5th Minor 3d	Perfect 5th Minor 3d
F	HYPO-LYDIAN......... (5th Church Mode)	Perfect 5th Major 3d	Perfect 5th Major 3d	Imperfect 5th Minor 3d
G	HYPO-PHRYGIAN..... (7th Church Mode)	Perfect 5th Major 3d	Perfect 5th Minor 3d	Perfect 5th Major 3d
A	HYPO-DORIAN......... (Modern Minor)	Perfect 5th Minor 3d	Perfect 5th Minor 3d	Perfect 5th Minor 3d
B	MIXO-LYDIAN	Imperfect 5th Minor 3d	Perfect 5th Major 3d	Perfect 5th Minor 3d

We may further see a very probable reason why, in the desire for variety, the Hypo-Dorian came to be chosen as our second modern mode, the minor; for that gives the tonic, dominant, and subdominant harmonies *all minor triads,* so forming (while keeping the fifths in all cases perfect) the most striking contrast to the major scale.*

The foregoing remarks apply to chords generally; but there are certain special relations attending the use of *discords,* or dissonant harmonies, which arise from their peculiar nature. These special relations are considered of great musical significance, in a practical point of view, and they form a very important feature in all treatises on harmony.

It is generally said that discords require something special *before* them, and something special *after* them. Or, as it is usually expressed in musical parlance, they require to be *prepared,* and *resolved.* We shall have something to say about the preparation hereafter; but as it is of minor interest, we may here deal with the more important element, the resolution of discords, which is considered strictly an affair of harmonic necessity. And although the rules have, in modern days, become very lax and wide, yet there is, undeniably, a feeling among musicians generally that a dissonant chord requires something after it specially related to itself, in a different way from any of those we have been considering.

Indeed, so firmly rooted is this idea in the practical musical mind, that it is customary, in some books on harmony, to make this supposed necessity the very definition of a discord. It is said that a consonance or concord is a combination which satisfies the ear of itself, giving a complete and satisfactory musical idea, without it being necessary for any other harmony to follow it; whereas a dissonance or discord is supposed to give an

* See also Helmholtz, pp. 378–380, 459–461, 464–467, 567.

incomplete musical idea, which does *not* satisfy the ear until it gets its proper following chord.

But, logically speaking, this definition is entirely begging the question. It is the old *argumentum ad aurem* over again. People are accustomed always to hear discords resolved, and therefore have come to assume the resolution to be a necessity; whereas, this necessity is the very thing we have to inquire into, and to prove, if possible, by independent means.

Let us therefore inquire a little more strictly into the nature of the feeling which appears to demand the resolution of a discord. Is there any foundation for it in the physical nature of things? Or is it, like so many other musical rules, merely æsthetical? Can it be traced to any definite principle?

In order to examine this in the clearest way, it is advisable to reduce the problem to its simplest form: let us go back to first principles, in the *elementary harmony* of two notes. It is only in this way one can disembarrass the question from the complications it acquires in actual practice.

We have seen that there are certain binary combinations which are esteemed *consonant*, and that all others are esteemed *dissonant*. The latter differ from the former in a way which has been explained, namely, that they sound *rougher*, by reason of the beats that they cause. This is absolutely *all* the difference, in a physical and physiological point of view, that characterises dissonances.

Is, therefore, this roughness of the combination sufficient to constitute a physical reason why it should be followed by any other particular combination?

Surely not. The roughness is a mere isolated fact, having reference to that particular combination and no other; and we may safely defy any one to show any necessary physical connexion between the beats

producing this roughness, and any fact or factor appertaining to the chord that follows.

If, therefore, this is so, we must come to the conclusion that the necessity for the resolution of discords is based on some foundation of another kind. We are, in fact, driven to ascribe the feeling to æsthetical causes; and when we thus get on the right scent, we shall not have much difficulty in finding the explanation.

There is every reason to believe that the feeling of the necessity for the resolution of a discord arises simply from the natural desire of the mind to *rest upon agreeable impressions,* rather than on disagreeable ones. This feeling is manifested in other branches of æsthetics in a great variety of ways. We tolerate disagreeable impressions, and often rather like them, if they are temporary, but we expect them to be followed by more agreeable ones on which the mind can repose. We do not object, in a novel, or a drama, or a poem, to situations involving anxiety and distress; they rather give interest to the action; but we expect them to cease, and to *resolve* themselves into more settled and satisfactory conditions.

A prominent manifestation of this feeling, in music, is in regard to the *close* of any piece or any long phrase. It is essential that such a close must be upon a *concord, i.e.,* a combination giving a naturally pleasant impression. And, so important was this considered by early writers, that they often objected to even the minor triad for this purpose, and in pieces in the minor key changed the last chord into major, so that nothing but the most satisfactory effect possible should end the piece.

Now, it would seem to be an entirely analogous feeling which leads us, when we hear a dissonant combination, to tolerate it for the time, and even to admire it as a distraction; but to insist on the condition that it shall be only temporary, and that, *as soon as may be,* a more agreeable sensation shall follow to satisfy and soothe the mind. This appears to offer a sufficient explanation of the feeling

of *incompleteness* which is attached to dissonances, and the rational existence of which we must admit. We have only to show that it is not a physical necessity, but arises out of the æsthetical principles that guide our mental sensations.

Hauptmann expresses this idea, but somewhat obscurely, when he says (p. 6), "The triad is consonant for uncultured as well as cultured persons; a dissonance requires a resolution for the non-musical as well as for the musical hearer; a discordance is something unmeaning for every ear."

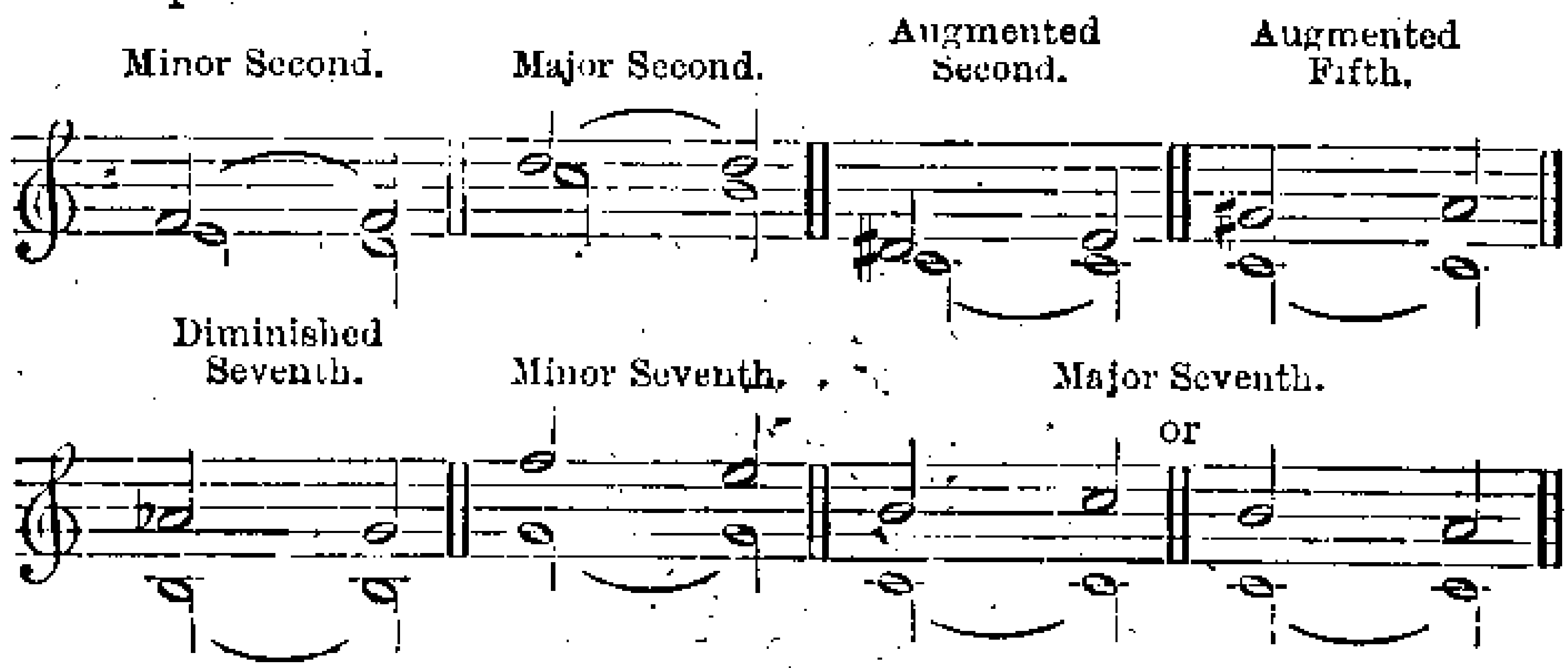
Helmholtz supports this view. He says (p. 514), "Dissonances are used generally to heighten the impression of musical progress and impetus; because, when the ear has been distressed by dissonances, it longs to return to the calm current of pure consonances."

But musicians will remind us that this explanation does not go far enough. It is not sufficient that the discord should be followed by a concord; the usual idea is, that it must be resolved *in a particular way.* This part of the question is more difficult than the former one, but still it admits of reasonable solution. It will simplify matters to confine our attention to the most elementary binary dissonances, as the manner of their resolution is clearer than when more complicated chords are used.

The rules for the resolution of dissonant notes are best explained by considering their historical origin. They came into being when music was chiefly *vocal*, and they were adapted in the most favourable way to the necessities and conveniences of the execution of music with the voice. They do not stand alone in this respect, for the contrapuntal rules generally were formed in a great measure for convenience in singing. In fact, as Richter remarks (p. 100), in strict counterpoint, even now, the parts are assumed to be *vocal.* Hence a rule arose that the passage from a discord to its following concord should be made

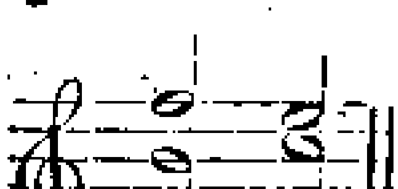
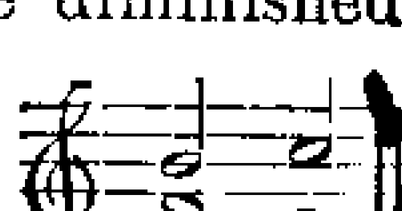
in the easiest way, and this way was naturally by single steps, diatonically, such steps being the easiest possible to take. In the early times a discord was considered an unusual, and, to a certain extent, an unnatural thing, involving an unwonted effort to the vocal powers to intone it properly; and hence the other old rule we have mentioned, that a discord should be *prepared*, *i.e.*, that the discordant note should not be taken by skip, but should exist in the preceding chord. Similarly, when the voice was upon the note, there would naturally be the same difficulty found in leaving the discordant sound as in getting upon it, and this would lead to a desire to make the step as easy as possible; whence the rule for resolution upon an adjoining note.

Some examples of the acknowledged resolutions of the two-note dissonances will show that this explanation fully corresponds with the fact:—



In all these cases one of the notes remains stationary, while, in order to get off the discord, the other moves one degree on to a note which will produce a following concord. This is evidently the easiest thing for voices to do, and it is most reasonable to infer that this facility has been the origin of the mode of resolution.

There are some dissonant binary combinations in which both parts usually move. For example, the diminished

fifth  or its inversion, the tritone, 

and the augmented sixth  These resolutions, however, are determined by more complex motives of the progression of the entire harmony, of which we shall speak by and by.

A few passages from Helmholtz may be quoted in support of the principles above laid down. He says (pp. 516–538, 548–550):—

"When dissonances are interspersed, the motion of the parts must be so contrived as to make the directions of the different melodial parts or voices perfectly easy to follow by the ear. Hence there are particular rules for the progression of these parts through discords.

"The motion of the parts must be so conducted that the hearer can feel throughout that the parts are pressed forward through the dissonance to a following consonance; and the anticipation of this approach is the only motive which justifies the existence of the discords.

"The dissonant notes of a discord form no part of its proper mass of tone, but may be considered as sounds unconnected with it accidentally *intruding;* hence particular laws have to be observed for the progression of the parts which contain this note.

"The feeling for the natural relations of such a dissonant sound is almost overpowered by the simultaneous sound of the other tones, and both singer and hearer are thrown upon the gradual diatonic progression as the only means of clearly fixing the melodic relations of such a dissonant note. Hence it is generally necessary that a dissonant note should enter and leave the chord by degrees of the scale."

Then Helmholtz explains why dissonant notes are most usually resolved by *descending;* he says descending motion is better suited than ascending motion to an extended note, for heightened pitch always gives involuntarily the impression of *greater effort*, because we have continually to exert our voice in order to reach or to sustain high tones. Illustrations of this are met with every day in the constant tendency of voices to *get flat* in singing or in reciting upon a fixed musical

tone. It is a singular fact that even trained singers like those in cathedral choirs usually find it impossible to intone a prayer without sinking considerably in the pitch of the note used; and it is a great feat for even picked artists to sing through a vocal unaccompanied piece without ending on a flatter pitch than they began. *Facilis descensus* is a thoroughly acknowleged principle in singing, and hence, if a singer has to get off his discordant note in the easiest manner, its descent becomes a matter of course. The note, as Helmholtz says, seems to *yield* in this way, and the descent becomes more analogous to the idea of repose which it is the object of the resolution to ensure. The few exceptions where a discordant note is quitted by ascent, are chiefly in those cases where the resolution can be got in that way by a *smaller step*, namely, a semitone, and therefore by an easier gradation.

We have hitherto only treated of the simplest resolutions of two-note dissonances. When we come to consider the resolutions of full discords of several notes, we have to take into account not only the movement of the separate notes, but also the progression of the harmonies, and here the general rules as to the progressions of harmony come into play. For as dissonant chords always contain some concordant elements, these have to be studied in their relationship to the chords which follow them, as already explained. Take, for example, the simple discord of the dominant seventh—G, B, D, F. It contains the major triad of the dominant, which, according to the principle of Rameau's "Basses fondamentales," is most naturally succeeded by the chord of the tonic, C, E, G. This, therefore, may be said to form the most natural resolution of the dominant seventh; and, in accordance with the before-mentioned principles for the treatment of the discordant note F, the easiest mode of its resolution will be for it to descend diatonically one degree upon the third of the new chord E. In regard to the movement of the

other notes, the G, representing the bass, most naturally moves to C, and the B finds its nearest and easiest progression in the semitone motion to C. The D may easily move a degree either upwards or downwards. This explains why, in the resolutions of the two-note combinations of the diminished fifth or the tritone (elements of the dominant seventh), each of the two parts has to move.

This kind of explanation will apply to dissonant chords in general, and it may now be easily seen that the resolutions of discords are governed by two reasonable rules:—

First, That the following chord should have a good and easy relationship, in a general sense, to the preceding one; and,

Secondly, That the dissonant notes shall pass by the easiest and simplest motions to their places in the next chord.

This is really as far as philosophical first principles can go; the exact details of resolution must be in each case matter of technical musical expediency, and the books are full of rules on the subject.

But too much stress must not be laid on the stringency of such rules. In the early days of harmony it was held that there was only one proper resolution to every discord; but modern practice has long since emancipated itself from such a restraint. Take only the case of the dominant seventh. The old rule (still taught in some books on harmony) was, that it *must* be resolved in the particular way above given. Now it has no less than *nine* modes of resolution, which are all used in some shape or other by musical writers, and may be considered as established in modern practice.

In fact, a clever composer may do almost anything he pleases, and we are every day becoming used to newer and newer combinations. Richter justly remarks (p. 86), in giving a survey of the history of harmony, "Everything has been subject to change; nothing has remained

in its original condition; all has undergone alteration and development. Startling combinations have been introduced and have taken root, and many things may yet be brought into practice that are yet unused."

Thus we are continually reminded that there is nothing fixed in the matter, so long as the minds and feelings of men are capable of æsthetical change.

CHAPTER XX.

COUNTERPOINT.

It only remains to say something about counterpoint. This is music written in a series of different *parts* for voices or instruments, each part having a melody of its own, and yet all combining, when performed together, into a harmonious whole.

The first kind of compound music used that had any pretension to method and system was contrapuntal. Harmony grew out of it, but did not supersede it, for the use of counterpoint, as one of the most interesting features of music, has lasted down to our day. It is true that we often get harmonious combinations of notes without any distinct separation of the various "parts" which produce them; but the highest class of music is that in which the two things are combined; and for the obvious reason, that then the mind gets a double interest at once, namely, that of the melodies of the separate parts, and that of the harmony of their combination.

We have here to do only with the foundation of the rules that have been established for the composition of counterpoint. And these are of two kinds: first, those which apply to the structure of the parts themselves; and secondly, those which affect their combination with each other.

In the first place, the various parts are to be considered singly, and are to be treated each as a separate melody; consequently, in writing them, certain rules of melody are

to be adhered to. In strict counterpoint the various parts are supposed to be *voices* (indeed, in German, the word *Stimmen*, "voices," is always used to denote the separate parts of a contrapuntal composition), and the rules were originally so framed as to facilitate the performance to the singers. The old musicians found out by experience that certain skips, chromatic transitions, and so on, were awkward and difficult for singers to take, especially when liable to be distracted by the other voices, and consequently, in strict counterpoint, these progressions were forbidden.

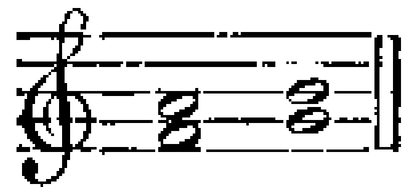
Then, secondly, there is a class of contrapuntal rules which have to do with the combination of the parts with each other. We cannot here go through the whole code, but a brief glance at some of them will illustrate their nature and origin.

Take, as the simplest form, the combination of two parts or voices together, note against note. In strict counterpoint the two notes must, when combined, only make *consonant* combinations with each other, dissonant combinations being forbidden. The reason of this rule is evident; the singers had to be guided by their ears in the justness of their intonation, and the consonant combinations were easier to sing in tune than the dissonant ones, as well as pleasanter in effect.

Then there is a rule against what are called *false relations;* for example, in the following passage— 

the C♯ in the second combination is said to have a false relation to the C♮ (an octave lower) in the first, and the progression is consequently forbidden. The reason of this is quite clear: the singer of the upper part would, having his neighbour's C♮ on his ear, find a difficulty in taking the C♯ promptly and in tune; and it is to the advantage of the music that this difficulty should not exist.

There is also an analogous objection to the *relation of the tritone; e.g.*, such a passage as the following



would be forbidden in the strictest counterpoint. This rule arose from the old prejudice against the "*Mi* contra *Fa*," it being assumed that the singer of the first part, having his neighbour's F impressed on his ear, would have a difficulty in intoning correctly the "diabolical" interval B♮ coming after it.

In other species of counterpoint, where several notes in succession are allowed to be used in one part against one note in the other part, discordant combinations are allowed to enter, thus—

but under the restriction that the discordant notes are to be taken and quitted, not by skips, but by single degrees of the scale. The reason obviously is, that the voice by this means is enabled to take them without difficulty, notwithstanding their want of consonant relation to the notes they accompany.

Similarly, in another species, discordant notes may enter by syncopation, thus—  for here the singer, being already on the note, has no difficulty in sustaining it. But the discord must be *resolved*, for the reasons already given in Chap. xix.

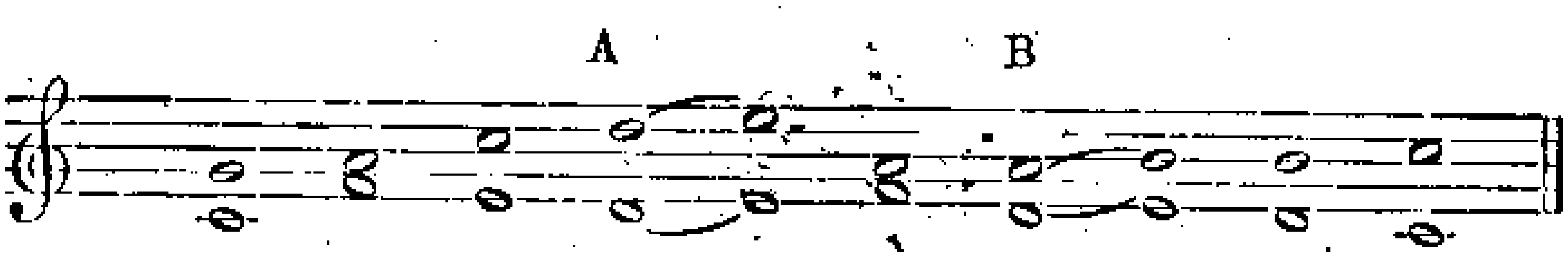
These are only a few examples of the rules laid down; but they will suffice to show that they have their origin in purely artistic expediency, in order to meet what, at the time such rules were framed, were considered necessities for good vocal performance.

Of course with instruments these necessities do not

occur, as the players can easily take any intervals they please, and hence the greater laxity with instrumental counterpoint; also, in vocal counterpoint in modern days, the ears of singers are so much more accustomed to the sound of discords that the intervals formerly so difficult become easier, and hence the rules for this are also relaxed. But still, to get vocal music well done, nicely in tune, each part should be easily singable; and therefore, although the old rules are not absolutely imperative, it is desirable they should be kept in mind, and attention to them, so far as is consistent with the character of the composition, will always improve its effectiveness.

We have postponed the mention of one rule of counterpoint which is very peculiar, and which it is necessary to discuss more fully, as its nature, origin, and import have given rise to much speculation. This is the law, so well known to all musicians, forbidding what are called *consecutive octaves* or *fifths*—that is, the motion of one part in octaves or perfect fifths with another part.

For example, the following passage



contains consecutive octaves at A and consecutive fifths at B. The Germans use the term *parallel* instead of consecutive, which perhaps conveys the meaning more accurately.

This rule is so thoroughly established, that the breach of it, generally speaking, is considered the highest crime a writer can commit; and the necessity of conforming to it is one of the first lessons given to students of composition. On this account, too, so sensitive do the ear and eye become, that the sound of a parallel octave or fifth in a composition when performed, or the sight of such a thing in a written score, becomes almost painful to a well-educated musician.

The rule is, moreover, of universal application, not only to the older style of writing, but to modern music of all kinds, both vocal and instrumental.

We have then to inquire, What is the foundation for such a stringent rule? And we will take the two elements of it in turn, as they differ considerably in nature.

In the first place, then, why is it forbidden that two different parts should move together in parallel octaves?

It requires but a very little consideration to show that the prohibition cannot be based on any natural or physical objection to such a progression. If we sound any succession of notes on a bright-toned instrument, we know perfectly well that, each of the notes being accompanied by the natural harmonics of its octave and its double octave, we get the very thing; and hence, so far from being prohibited, consecutive octaves are held up to us by nature as a model to be imitated rather than avoided. But, more than this, in music of all ages, ancient as well as modern, the movement of different voices and instruments in consecutive octaves, for long passages together, has been practised without the slightest objection. Indeed, it constitutes a large and important feature in modern compositions. Hence, there can clearly be no objection to parallel octaves on natural grounds. The objection is entirely an *artistic* one, as can soon be shown.

What is counterpoint? It is a series of *different* melodies going together.

When a man and woman sing the same melody, moving in octaves to each other, the melody is the *same;* and here the distinguishing feature of counterpoint, *i.e.*, the combination of *different* melodies, fails. In other words, such a combination is no counterpoint at all.

If, then, we *profess* to use different melodies, and yet, in any part of them, allow two voices to move together in octaves, in that part the composition ceases to be true counterpoint. We profess to keep the melodies different

throughout; but wherever consecutive octaves occur, this condition is broken, and for this reason, and this only, are consecutive octaves forbidden.

The rule as to parallel *fifths* is much more difficult to account for, and has always been a great puzzle.

It is asserted, and generally believed, that there is something naturally repugnant to the ear in such successions as these—  And we have certainly this great practical distinction between consecutive octaves and consecutive fifths, that we do not find, in modern music, successions of perfect fifths used in the same way as successions of octaves.

But still it is undeniable that any series of musical sounds will be accompanied naturally by consecutive fifths as well as by consecutive octaves; and with this example in nature before us, it certainly seems difficult to say that such sequences are forbidden by natural laws.

We are bound to distrust here the appeal to the ear which we have so often protested against. It cannot be denied that a succession of perfect fifths in counterpoint sounds very objectionable to musicians. But it must be recollected that from the first moment any musician began to study composition, he was taught to hold consecutive fifths in abhorrence; and it is to be expected that the result of this must be to make him believe that they are naturally objectionable. If there is really any physical or physiological cause for the antipathy, it ought to be capable of being *shown;* if it cannot be shown, we have a right to presume it is merely the effect of education and habit, and therefore is of no weight in the logical argument. We know one thing by experience, namely, that these fifths do not sound offensive to those who happen to be ignorant of the rule against them. There are

many persons who have learnt music practically, and been accustomed to it all their lives, but who have never had a lesson in harmony or composition; and if such people attempt to write music in parts, they will use consecutive fifths without the slightest hesitation, and not see anything objectionable in them;—rather a strong argument, it would seem, that the objection arises chiefly from a knowledge of the rule.

Very few writers on harmony have given themselves the trouble to say, or to think, anything about the explanation of this rule. They have usually taken it for granted, as a self-evident proposition, that fifths are to be abhorred and avoided. It is interesting to see, however, what *has* been said by some of the more thoughtful writers.

Hauptmann expresses himself on the subject in this way (p. 65):—

"For proficients in contrapuntal harmony, the prohibition of parallel fifths is unnecessary; for a right feeling for the essence of progression will spontaneously exclude them.

"With a parallel fifth, however it may be covered, the signification will always make itself heard, that against a first triad which stands as a beginning, a *second* triad is endeavouring to set itself up *also* as a beginning. This gives the impression of egoism among the chords (*Akkordegoismus*), which destroys the unity of the composition.

"Octaves and fifths are forbidden with equal propriety, for both have a bad effect; but the reason of the bad effect differs in the two cases. With octaves we lose the necessary *variety in the melody;* with fifths we lose the necessary *unity in the harmony.*

"Octaves may be allowed between parts that do not pretend to variety, but fifths never, since an unconnected harmony belongs to no proper artistic system."

Richter, after explaining the object of the rule against octaves, says (p. 16):—

"The ground of the rule against fifths is more difficult to establish, although people have been fully convinced of its necessity; and

many endeavours have been made to express this necessity clearly and definitely. I offer the following views for consideration :—

"'Every form of chord, which is included chiefly between its root and fifth like a circle, let it be otherwise constituted as it may, represents in itself a *closed whole*. And since harmonic connexions can only be effected by one chord passing into and upon others, it is evident that two chords with such fixed boundaries, fifth after fifth, cannot pass into each other, but must, when they stand side by side, appear unrelated and unconnected.

"'Whenever, therefore, a perfect fifth appears, it will carry with it its character of limitation (*Abgrenzung*), and the disagreeable quality of the succession of two perfect fifths will be found to be in their want of connexion—in their isolation.'"

He mentions many cases where the rule may be relaxed.

Helmholtz goes into this matter, but not very clearly. He points out (p. 559) forcibly by several arguments that consecutive fifths are not disagreeable to the natural ear, instancing the constant presence of them in all brilliant tones, and in the compound stops of the organ. He says, therefore, that the law against them can only be founded on their infringing the laws of artistic composition.

He appears to consider the rule an *extension* of the one for octaves, and justified by the same grounds. He says that twelfths (which may be considered as representing the fifths), when used as a consecutive accompaniment, merely *strengthen the fundamental* sounds, and do not add any new independent element to the harmony; and hence an accompaniment in twelfths or fifths is a breach of the artistic propriety which would require *independent composition*. He adds—

"The prohibition of consecutive fifths was perhaps a *reaction* against the first rude attempts at polyphonic music, which were confined to an accompaniment in fourths or fifths, and then, like all reactions, it was carried too far, in a barren mechanical period, till absolute purity from consecutive fifths became one of the principal characteristics of good musical composition."

Helmholtz's view as to the contrast between the old diaphony and the later counterpoint is corroborated by

other authorities. Coussemaker says, speaking of the former—

"La diaphonie, dans son origine, n'avait pour destination que le reinforcement de la melodie principale par l'addition de quintes, d'octaves, et de quartes, entremêlées accessoirement comme les sons secondaires dans le jeu de mixture de l'orgue."

And we may gather the same argument from the following extracts from Zarlino (Istituzione Armoniche, 1571), who was the first, after counterpoint had been well established on good models, to reduce it to rule. He says:—

"Vietavano i più antichi compositori il porre due consonanze perfette di uno istesso genere e specie, contenute nei loro estremi da una proporzione istessa l'una dopo l'altra, movendosi le modulazioni per uno o per più gradi; come il porre due o più unisoni, over due o più ottave, overamente due o più *quinte* et altre simili; conciò che molto bene sapevano che *l'armonia non può nascere se non da cose tra loro diverse, discordante, e contrarie, e non da quelle che in ogni cose si convengono.*"

He then makes, in illustration of this principle, the philosophical remark that Nature produces no individual of any species which is exactly similar to any other individual; and he adds—

"Debbe adunque ogni compositore imitare un tale e tanto bello ordine; perciò che sarà riputato tanto migliore quanto le sue operazione si assimiglieranno a quelle della natura."

This makes it conclusive that the original founders of the rule forbidding consecutive fifths based it entirely on the same ground as that forbidding octaves and unisons, namely, the essential *similarity* of the two parts in such progressions, and the necessity of avoiding this, by contrariety and diversity, if the good character of the counterpoint was to be maintained.

At the end of the history of harmony, allusion was made to the felicitous description given by Dr. Hullah, of counterpoint and harmony respectively, by the terms *horizontal* and *perpendicular* music; and attention was

called to the change that took place about the seventeenth and eighteenth centuries, by greater prominence being given to the vertical element or harmony. Since that time the interest of composers in the horizontal element, or counterpoint, has unfortunately much fallen off. Some few later men of eminence, among whom Mozart and Mendelssohn shine prominent, have indeed cultivated and written good counterpoint; but the majority of modern writers look on it as an antiquated and exploded art, and trouble themselves so little about it, that it might almost be considered extinct. It is doubtful if any musician now alive could write a motet which should be mistaken for Palestrina, or a madrigal which could be attributed to Luca Marenzio, or a Church anthem like one by Orlando Gibbons, or a chorus like one of Handel's, or an organ fugue like one by Sebastian Bach.

It is to the want of this *horizontal* element of interest, that the choral compositions of modern days sound so insipid and so poor in comparison with those of older date. Music, in parts, still nominally remains; and indeed, in instrumental music, we have more parts in a score than ever were known before; but it is astonishing how little real counterpoint there is in the majority of modern compositions, the parts usually filling in the harmonies with but little individuality of their own. We have now no longer a series of melodies for the different voices, but usually only one for the soprano, the others taking the ignoble position of forming only an accompaniment thereto. The fashionable modern title, "part-song," expresses this; compositions so called are merely melodies harmonized vertically, and not combined horizontal and vertical music, like the old many-voiced compositions.

Modern music waits in this respect its deliverer from its present poverty of resource; and the composer of the future who will restore the lost contrapuntal interest, in connexion with the enlarged resources of modern harmony, will make himself a great name.

Hauptmann was a great teacher as well as a great admirer of good counterpoint, and he expressed himself strongly on its modern neglect. The following extracts from his *Letters to Hauser* are worth quoting:—

"The ancient polyphonic music was a combination of melodies which were so contrived as to go together. The modern is merely successions of chords divided among several parts; the effects of harmony. which in the former case arose out of the combination, are in the latter the datum of the composition. And although the old music was often defective in the harmony, the new is more so by the repulsive and unnatural motion of the parts; so that, judged from the proper point of view for part-writing, much of the modern music is more barbarous than the first contrapuntal attempts. In the works, however, of the more advanced middle age, we may see how the greatest of all musicians have succeeded in satisfying both conditions, the interest of the parts and the resulting harmony, with a perfection never approached in later times (I. 27).

"I have pointed out in a recent criticism, that the instruction in what is called 'thorough bass' does not suffice for the writing of counterpoint: it teaches nothing of the conduct of the parts (*Stimmführung*). It is true that harmony is reckoned the most important thing in our music, but if harmony is to be worth anything, it ought to arise out of the melodies of the separate parts; and if any one wishes to do this well, he must have gone through the whole history of music from 1400 to 1800. It is natural that the wants of to-day should have most claims on him, but if he has not narrow-minded views, he ought first to go back farther and farther, and then retrace his steps to a modern date, for only in this way will the music of to-day acquire any living soul (I. 226).

[Speaking in praise of Mendelsshon's St. Paul]. "We see what a difference there is between the choral music of all other modern composers and these genuine Corales, woven out of melodies, where every one willingly sings, because he has something to sing (I. 261).

"The true meaning of harmony is, that it arises from a combination of melodies sounded simultaneously. This, which was the most important thing in olden times, is now neglected. In good modern writing, the bass is indeed given good relations to the melody, but the middle parts are filled in with rubbish simply to complete the chords. The lifted pedal will then bind the whole into a compact mass, but any organisation in it is out of the question. I have nothing to say against all this, but would rather have nothing to do with it (I. 281).

"Palestrina's music has all its separate parts so beautiful, that one would like to sing them all one's self. How many composers there are who could not better employ their time than by writing out music of this kind! (I. 289.)

"Most people know nothing, and care nothing, of what true harmony means. By means of the clavier, through which all musical education is now conducted, they get a certain feeling for compact harmonies, but learn nothing of the consonance of melodies. Few persons can write easily a four-part chorale as it ought to be, *i.e.*, forming itself naturally and free out of four-voice parts, each unconstrained. Many a writer of great heaven-and-earth-storming symphonies would be unable to do this, although he probably would be unaware of his own deficiency (II. 136).

"I certainly disagree with those who assert that counterpoint and fugue are of no use. It is as in the modern schools, where Latin and Greek are omitted, on the ground that they are not used in after-life. Latin and Greek once learned may be forgotten, but the scaffolding on which the learning has been built in the school remains standing, though invisible, and gives a support to all knowledge; so do counterpoint and fugue give to harmony a life, and a flexibility, that make out of a compact mass a living and well-organised entity. Perhaps a musician may have as little occasion to write fugues as to speak Latin; but his waltzes and songs will at once betray what he knows of composition, and we should obtain lightness and facility, instead of that egoistical oppressiveness which weighs us down like a huge alp in so much of our modern music" (II. 205).

CHAPTER XXI.

CONCLUSION.

It may be well now to make out a brief summary of the results at which we have arrived in the investigation we have been through.

Our object was to institute a philosophical inquiry into the general structure of music, in order to ascertain how far it was based on physical data, or how far it had been the result of æsthetic or artistic considerations. And we may formulate our conclusions as follows:—

The material of music consists of *musical sounds,* which are produced by various natural or artificial means.

The production of a musical sound is due to vibrations of the sonorous body succeeding each other at regular intervals of time.

The *pitch* of a musical sound is due to the *rapidity* of these vibrations; and the *loudness* of the sound is due to their extent or *amplitude.*

A musical sound of ordinary quality, although it is usually considered to represent a single note, is really a *compound* sound, consisting of this note as a fundamental, accompanied by several other notes, above it, called *overtones.*

These overtones have a certain fixed relation to the fundamental; their rapidities of vibration being simple multiples of that of the fundamental note.

The first, and usually the most prominent, overtone

The second overtone, which is next in prominence, sounds the *twelfth*, or *octave fifth*, of the fundamental.

These overtones can be easily appreciated by the ear, when musical sounds of a tolerably brilliant quality are heard.

Hence, the intervals of the *octave* and the *fifth* may be said to be *dictated by nature*, as resulting from the natural constitution of musical sounds.

The number and comparative strength of the overtones vary in different sounds; and these variations determine the *character* of the compound sound.

The overtones also exercise an important influence on the *use* of musical sounds, and on the structure of music.

Passing on, therefore, to investigate this use of the material of music, we find, in the first place, that—

Musical sounds must not be chosen indiscriminately from the infinite number possible. Before music can be made, an *elementary series* of sounds must be arranged, differing in pitch by definite steps or gradations, and called a musical *scale;* and the sounds used to form music must be taken from this scale.

The necessity of this is due to an æsthetic cause, the mind requiring these definite steps in order properly to appreciate the *motion in pitch* constituting melody.

The *arrangement* of the steps in forming scales may admit of considerable variety, and it is actually found to have varied considerably among different nations.

In almost all cases, however, where music has been cultivated, the two *natural intervals* of the *octave* and *fifth* have formed steps in the scale.

The scale *we* use was first established by the Greeks, about five or six centuries before the Christian era, and is called the *diatonic scale.*

In it the octave and fifth are recognised as the most important steps. The other steps are irregular, and were

in modern times been subject to slight alterations, so as to make them more suitable for the introduction of harmony.

Our scale is also augmented by additional sounds, called *chromatic* notes, used accidentally.

The *exact pitch* of these chromatic notes has been subject to difficulty and disagreement; but it may be determined by a proper consideration of the object they are intended to serve.

The whole modern scale, of diatonic and chromatic notes together, may be approximately represented by the division of the octave into twelve equal parts, called *mean semitones;* which is the scale usually adopted in modern music, and expressed by the keys of the pianoforte.

In the earlier times of Greek music, it was the custom to form melodies from different octave-forms of the diatonic scale, each having the unequal intervals or steps arranged in different order, and constituting different *modes.*

Some of these were adopted in the music of the ancient Christian Church; and special prominence was also given to *one particular note* of the scale used.

This was much further developed at a later time, and it resulted in the reduction of the modes to two, known as the major and minor (which were the best calculated for harmonic use), and in the more paramount importance of one note, constituting the principle of *modern tonality.*

All these modal and tonal introductions and changes were of purely æsthetic origin, having in view the improvement of the artistic construction, and the offering to the mind of new elements of interest, in addition to the mere succession of sounds.

It is therefore a mistake to suppose, as many people do, that there is any *natural necessity* for the arrangement of modes and keys which we at present use.

arose a more systematic and continuous *measurement* of the duration; which became subsequently developed into the elaborate arrangements of time, rhythm, and form, that now characterise modern music.

This also is of æsthetic origin, its motive being, as before, to present new features of interest to the mind.

Taking, lastly, the complex structure of music, we find that this consists of two elements, *melody* and *harmony*.

Melody is the oldest, and for a long period was the only form of music used.

The one absolute requirement for melody is, that its notes must be taken from an acknowledged scale; but modern melody is usually required also to have tonality, measure, and rhythm.

The qualities which determine the agreeableness of melody are entirely æsthetic, and do not admit of being reduced to rule.

Coming now to the subject of harmony we find—

In early periods people were led, by the natural suggestion of the *octave* interval, to accompany melodies in this interval.

This was practised by the Greeks; but there is no positive evidence that any further systematic attempts at combining different sounds were made by them.

Soon after the beginning of the Christian era, traces appear of an accompaniment in the two other most consonant intervals, namely, the fifth and the fourth; and there is proof that the accompaniment of melodies by *similar melodies* in the octave, fifth, or fourth, formed the kind of harmony used in Church music during about the first thousand years of our present era.

Subsequently the plan arose of accompanying a melody, not by a *similar* melody in different intervals, but by a *different* melody; then *more than one* accompanying melody was added, and this formed *counterpoint*, *i.e.*, the *union of different melodies together*.

This union necessarily produced varied combinations of sounds, and so arose *complex harmony*, which ultimately took a separate existence and form, independent of the counterpoint in which it had its origin.

In studying the theoretical nature of modern harmony we found it desirable to begin with the simplest combinations, namely, those of two sounds together: these forming the elements out of which the more complex forms may be assumed to be built up.

A large number of these binary combinations may be formed from the notes of the ordinary scales; but they vary in their effect on the ear, some being generally considered *smoother* and more *agreeable* than others.

These differences are traceable to real *physical* causes, dependent on the natural constitution of musical sounds.

They arise, chiefly, from the interference with each other of the *overtones* of the two notes; which cause *beats*, resulting, when at a certain velocity, in roughness or harshness. They are also affected in some degree by the natural production of additional resultant sounds.

With the more agreeable combinations, called *consonances*, the roughness is comparatively slight; with the less agreeable ones, called *dissonances*, it is more marked.

There is, however, physically, no strict line of demarcation between the two.

Passing on to combinations of several notes, or chords, we find they may be considered as built up of elementary binary combinations; and the analysis of these will enable an estimate to be made, on physical principles, of the comparative effect of each chord, as regards its degree of dissonance.

The effect, so estimated, agrees with the practical musical character of the chord, which, therefore, may be pronounced to have a physical basis.

There is one chord, namely, the major triad, distinguished from all others as being suggested by nature, since it is audibly present in the most prominent har-

monics of compound sounds. This chord has always been, and still is, the most important chord in practical music.

Nature also dictates a certain position and a certain prominence for one of the notes of this chord; and this is also recognised in musical practice as the most natural and satisfactory.

But no *other* combinations of notes can be traced to such a direct physical origin; hence the derivations of other chords must be only partial and indirect, and they must be considered more or less *artificial.*

Many dissonant combinations of notes, although very harsh in themselves, will be tolerated by the ear, and will pass almost unnoticed, if at the time they occur some other element of musical interest is offered prominently to the mind. This æsthetical consideration will account for many apparent difficulties in practical harmony.

In regard to harmonic *progressions,* we find that there is no *physical* reason why any one combination of notes should be preceded or followed by any other combination; but that an æsthetic feeling exists requiring the progressions to be united by some kind of *relation* which the mind can appreciate.

These relations may be of several kinds, but there is one of the most important which is founded on the physical properties of musical sounds.

The musical doctrine of the *resolution of discords* depends entirely on the æsthetical desire to pass from less agreeable to more agreeable impressions; and the *modes* of resolution have been dictated by attention to artistic structure.

Other rules in regard to the motion of the parts in counterpoint, and other details of practical composition, have had a similar artistic origin.

If these propositions have been proved, they will certainly establish the opinion given in an early part of this

work, namely, that although the fabric of music has its foundation laid in natural phenomena, yet its superstructure is almost entirely a work of art. The analogy of a building is, in fact, perfectly applicable. The foundation and strength-giving portions of every important edifice must comply with determinate and invariable physical laws of stability, but the details and decorative features may be anything that the architect thinks desirable. So with music. The great architects who have, in progress of time, built up the structure of music we at present admire, have adhered to certain main principles of real physical origin; but in filling up the details beyond these they have been guided either by the requirements of artistic combination, or by the suggestions of æsthetical taste, or perhaps, in some degree, by the promptings of their own genius and originality.

This result, differing so essentially from the ideas heretofore generally held among musical men, can hardly be expected to be received by them without hesitation. The idea of the necessary natural origin of all musical forms and rules, groundless as it is, has taken such firm hold, that it cannot be eradicated quickly. Cases are not rare, in the present day, where new philosophical systems constructed with the accuracy of modern scientific reasoning, have had to elbow aside long and dearly-cherished delusions, and so it will be with the scientific theory of music. It will be reserved probably for musicians of the next generation to adopt the more advanced views, and the wonder will then be (as it is now in regard to many abandoned errors) that the acceptance of the truth should have been so long delayed.

One thing may, however, be pointed out, which, when well considered, ought to further the acceptance of the philosophical views; namely, how much they tend to exalt the art of music, and the merits of the great composers. The ordinary belief, that everything that a great musician writes ought to be "accounted for," *i.e.*, brought

into conformity with some imagined natural rule, is no very complimentary tribute to his genius; it is infinitely more ennobling to believe, as the philosophical theory leads us to believe, that the musical forms are really the outcome of the composer's own art—the offspring of his instinctive perception of what is pleasing.

We have treated, in the foregoing chapters, of little beyond the two main elements of composition—melody and harmony; but the artist has gone far beyond these: he has introduced refinements which lie quite out of the pale of philosophical investigation. All such things as the force and delicacy of expression; the gradations of *forte* and *piano*, the graces of ornamentation; the combinations of different qualities of tone, in the rich choice of voices and instruments; the changes of tonality by modulation, in hundreds of different ways; the multitudinous varieties of measure, rhythm, accent, and emphasis; the manifold arrangements of structural *form*,—all these are pure inventions of the composer's artistic mind.

But, further than this, the composer of true genius lays claim to a much higher and nobler power: that of touching the heart, of stirring the emotions, of exciting the passions, even of suggesting phases of sentiment and states of mind; he can breathe into his music the breath of life, and give it a living soul. This is a wonderful and mysterious faculty; its mode of operation eludes detection, and defies philosophical reasoning. But its reality is beyond question. The deeds of Orpheus and Timotheus may be fables; but the impressions produced by the works of Handel, of Mozart, or of Beethoven, can be ignored by none who have human sympathies and human ears.

The relations we have pointed out between the physical and æsthetical elements in musical structure are abundantly confirmed by the facts of history. The simpler

features, which we have traced to a natural origin, have been permanent and unchangeable; while the more complex developments due to æsthetical and artistic feeling have been constantly subject to change.

The chief divisions of the scale—the general preference for the smoother harmonic combinations, and the predominance of the more natural harmonic relations—are just as much in force now as they ever were, and probably will always continue so. But in no part of the more *complex structure* of music has such stability been observable. A constant development has been taking place, each century having abolished the strict limits established in preceding ones, and extended the boundaries of the art by gradual but certain advance. Almost every novelty has been questioned and opposed, on the ground of its supposed incompatibility with some assumed law; but the opposition has vanished, as it naturally must, from the fact that the assumed law was only of artificial origin, and could be abrogated by the same influence as that to which it owed its rise.

There is an anecdote of Beethoven which admirably illustrates this point. Some critic remarked that a certain passage in one of his later works was "not allowed." "Then," replied the composer, "*I allow it;* let that be its justification." Those three words are worth a whole essay on the theory of music; for they imply that the laws for its artistic structure must be largely dependent on the practice of the greatest composers.

If, however, we have succeeded in showing that the construction of music is, to a large extent, determined by æsthetical choice and not by fixed natural laws, we must not commit the error of ignoring the value of rules for musical composition.

Whatever the motives may have been that have influenced composers, it is an undeniable fact that there has

authorities, at any given date, as to how music should be written; and we may therefore take it for granted that the structure chosen for it is, under the circumstances of the time, an advisable one.

Hence, what is more natural and more beneficial than that attempts should be made to define and describe the structure of music as found in the best composers, and to devise rules by which students can be directed to follow the practice of the great masters in their own attempts at composition? We may here repeat an analogy used more than once in this treatise, that of grammar in literature. Nobody pretends that the forms of speech are dictated by immutable natural laws, they have grown up, no one knows how; but such as they are we find them exemplified in the works of the best writers, and we must accept their usages as authoritative. And since it is necessary that learners should have some safe guide to enable them to speak and write in accordance with the received forms, the plan is adopted of framing rules of grammar and syntax, which, however, pretend to no authority in themselves, being merely a commentary on the examples found in the writings taken for models.

Let then, by all means, similar rules for musical composition be established and enforced; but, at the same time, let it be properly understood what they mean. Do not tell the student that such and such combinations, such and such progressions, are dictated by an unquestionable origin in natural necessity or natural laws, and that to violate them is a crime against philosophy and science. Tell him instead that they have been agreed to by the common consent of the best composers, and that for him to ignore or refuse to follow them is an offence of the same nature as it would be wilfully to write incorrect English, or to do any other act at variance with the ordinary practice of mankind. If he pleads, as an ardent and aspiring student may, that, in accordance with the principles here laid down, great composers have the privi-

lege of making or altering musical rules for themselves, or of introducing novelties at their pleasure, it will be sufficient to suggest to him that he may wait till he becomes a great composer before he ventures to put the principle into practice, and that in the meantime his study will best be furthered by following the beaten paths.

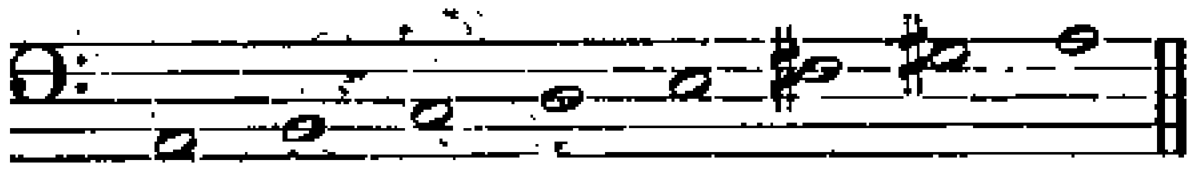
This will be far better than to attempt to coerce him by untenable assumptions, the fallacy of which, if he has any good reasoning powers, he cannot fail, sooner or later, clearly to see. And when the true scientific philosophy of music is once understood, it will at least have the useful practical effect that it will prevent the study of the art of composition from being hampered and obstructed, as it so often is at present, by theoretical complications at once unnecessary, imperfect, and unsound.

APPENDIX.

NOTE A.—*Page* 128.

THE ANCIENT MODES.

MUCH more might be said, than has been said in the text, as to the use of the ancient modes. The great obstacle to any intelligent understanding of the subject is the fallacious idea so deeply rooted in modern minds, that our major mode, with its indispensable "leading note," is the only natural and proper form in which music ought to be written. As a consequence of this, even the minor mode, though admitted in name, is, in a great measure, deprived of its proper character by its forced assimilation to the major form in the "accidental" sharpening of the sixth and seventh. The ascending minor scale as usually given



is really not a diatonic scale at all, as it abandons the established diatonic order of succession of tones and semitones: it is only in the descending form that this is preserved. The restoration, however, of the *sixth* to its proper degree, which has lately been so much insisted on by the strongest-minded and most intellectual musicians, must be regarded as a protest, as far as it goes, against the effeminate alteration; and it is by no means improbable that a reaction may take place as to the seventh also, so as to bring the ancient Hypo-Dorian again into its true characteristic form. It is undoubted that many of the old popular melodies, for which the minor mode was so much used, were written with the unaltered minor seventh. Modern musicians say in regard to this, that "they could not have been sung so, as the ear of the singers would naturally have led them to sharpen

the seventh;" but this is simply begging the whole question, by a gratuitous and fallacious assumption that the human ear had, centuries ago, the propensities due to modern training. It is an absurd anachronism to suppose that the ancient singers were of necessity imbued with the principles of a system that did not come into general use till long after their day. It is true that we learn on good evidence, that it was customary, in the old ecclesiastical music, for singers to make occasional chromatic changes, and modern musicians have jumped to the conclusion that these were for the purpose of assimilating the scale to the modern modes; but this, it appears to me, is a hypothesis for which as yet no sufficient proof has been given: the best known case is the alteration of the B♮ to B♭ in the fifth Church mode; but this had clearly for its object the avoidance of the dreaded *Mi contra Fa* with the tonic F, and has no bearing on the question. It would be very desirable to investigate further, as a matter of history, what these alterations were, and when they were introduced; but at present, I doubt whether it has been shown that there was any strongly-marked tendency to sharpen the seventh of the scale (in modes which required it to be minor) before the predominance of the Lydian tonality.

The appeal to modern ears on this subject is, of course, a fallacy; what people who use this argument call a "natural" desire for a leading note, merely means a desire to hear what they have been accustomed to, and taught to consider proper. No proof has ever been given of any real tendency of the kind; indeed, cases to the contrary are continually occurring, and there is great doubt whether the ordinary musical public would manifest the so-called natural desire for the leading note unless they were prompted thereto. One of the tunes in "Hymns Ancient and Modern," *Veni Immanuel*, retains the cadence with the minor seventh in its old form, and is sung by congregations without hesitation. And to go to lighter music, a certain very popular modern song ends thus—

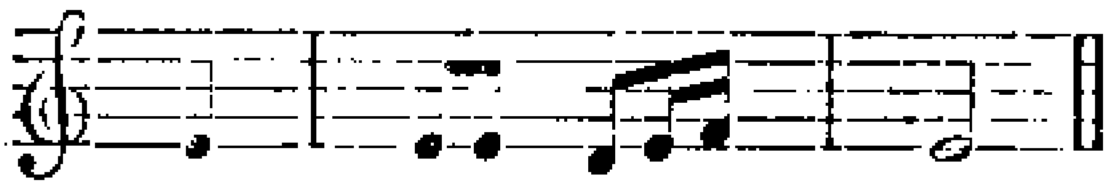
and hundreds of young ladies sing this in drawing-rooms without ever discovering anything unnatural about it, till the music master comes in and "corrects" the F♮ to F♯.

It is a consequence of the short-sighted view of the exclusive propriety of the modern major mode, that it is next to impossible for those who hold it to form any correct idea of what the varieties of octave-forms mean, as they have acquired an ineradicable tendency to refer every passage of music they see or hear to the modern tonality. Thus, if we were to play, to a modern musician, the seven octave-forms exemplified in the diagram on page 114, and ask him what he thought about their tonality, he would confidently answer that they were all in the same mode, and in "the key of C major," and one would hardly know how to make him understand his error.

There are plenty of examples of the old modes which are accessible enough. The richest variety is to be found in the Church melodies, many of which, in the various forms, are cited by M. Gevaert. But the unlucky prepossession of modern musicians has led them often to commit the anachronism of adding to these melodies harmonies constructed according to the modern tonality, so converting them into a hybrid nondescript kind of music from which it is impossible to form any correct idea of the real character of the originals.

Professor Macfarren, in his "Lectures on Harmony" (First Edition, 1867), has given a good account of the Greek modes (except that he has used the names of Glareanus instead of the true Greek terms), and has shown their connexion with those used in the Church. He has also given several useful instances of their application in a comparatively late period. For example, the subject of Handel's fugue in *Israel in Egypt*, "And I will exalt him," is in the Greek Phrygian, while "Egypt was glad when they departed" is in the Greek Dorian; and although the harmonic treatment conforms occasionally to modern tonal principles, yet there is much of the strong antique character preserved. Indeed, in the whole range of polyphonic music which lasted from the time of Josquin des Près to that of Bach and Handel, evidences of the old modes are distinctly traceable, and signs of them may even still be found in some effective points in perfectly modern compositions. Mr. Macfarren points out,

with great truth, the influence of the Dorian mode in the touching passage in the first duet in Mendelssohn's *Elijah* "Lord, bow Thine ear to our Prayer," and Helmholtz (p. 473



and following) not only mentions many fine applications of the Dorian form in the works of Handel, Bach, Mozart, and others, but traces directly to it the origin of two of the most effective chords in modern use, the Neapolitan and the augmented sixths.

Many popular melodies have been also quoted as exemplifications of the ancient modes. Mr. Macfarren instances an old English one "Cold and raw" as decided Phrygian, and M. Gevaert gives a large variety. He takes many Irish airs from Bunting's "Ancient Music of Ireland," including six in the Phrygian and eight in the Hypo-Phrygian modes; and also quotes other nationalities. One of the most striking is a Spanish air to a well-known ballad, said to be of a comparatively late origin, dating towards the end of the fifteenth century. The two first lines might pass, if alone, for Hypo-Dorian, but the ending stamps it as Dorian.

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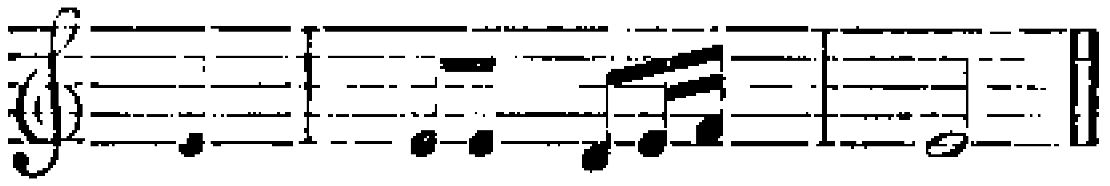

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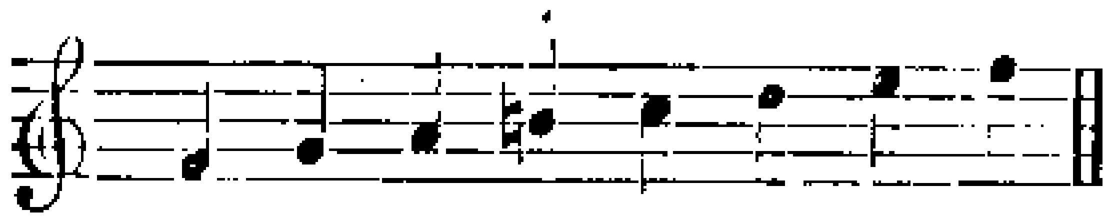
corale in Beethoven's quartett, No. 15, Op. 132. It is entitled "Heiliger Dankgesang eines Genesenen an die Gottheit, in der Lydischen Tonart," or "Sacred Song in the Lydian Mode, offered to the Divinity in Gratitude for a Cure." Beethoven, it must be explained, uses the ecclesiastical or Glareanus name, Lydian, which corresponds to the Greek Hypo-Lydian; and the idea is most consistently carried out. The corale is harmonised in four parts, but the harmony is kept strictly in the mode. The tonic is F, but the B is natural, the scale being



and this is rigidly adhered to throughout; an example of consistency and propriety which ought to have found more imitators among those who rush into meddling with the ancient modes without the requisite knowledge, judgment, or principle.[1]

Some very interesting examples of the ancient modes have been lately published by Monsieur L. A. Bourgault-Ducoudray, Professor of Musical History at the Paris Conservatoire de Musique. M. Ducoudray was commissioned by the French Government, in 1875, to undertake a mission to Greece and the East, for the purpose of studying the character of the national and popular music of those parts. In 1878 he published a brochure containing an account of his researches, and this was accompanied by two musical works, namely, "Etudes sur la Musique Ecclesiastique Grecque:" Paris, Hachette; and "Trente Melodies populaires de Grèce et D'Orient:" Paris, Lemoine.

The latter work presents a series of airs of a very original kind, founded either on the ancient Greek modes or on peculiar scales used in the localities. They are given strictly in their original melodial forms, but, in order to add interest to them, an attempt has been made to adapt harmony to them in the shape of a pianoforte accompaniment, adhering (on Beethoven's plan) strictly to the character of the modes, and keeping free from the interference of any incongruous modern tonal ideas.

[1] The author of this work, in the exercise for his Doctor's degree, in 1867, ventured to give some examples of a Canto Fermo, set for eight voices, in the various modes, on this plan.

Full explanations accompany the music, and the following extracts from the Preface will illustrate the views of the author on the question we are now discussing:—

"The majority of these airs are constructed according to the principles of the ancient modes.

"We have imposed on ourselves the rule never to touch the melody for the necessities of harmony; on the contrary, we have made the harmony obey the melody, forcing ourselves to preserve, in the accompaniments, the character of the *mode* to which the melody belongs. We have not interdicted the use of any harmonic combination, except such as appeared to us inconsistent with the *modal impression* engendered by the melody under treatment. Our efforts have had for their object to enlarge the circle of the modalities in polyphonic music, and not to restrict the resources of modern harmony. We could not bind ourselves, by the rules of the past, in an attempt which is new; if it finds imitators, the sanction for it must be reserved for the future.

"We hope to have shown how much fecundity there is in the application of harmony to the Eastern scales. Western polyphonic music, hitherto confined to the use of two modes, may by this means escape from its long reclusion; and the fruit of this deliverance may be to furnish resources of expression altogether new, and colours which hitherto have been unknown to the pallette of the musician.

M. Ducoudray has been lately giving a series of lectures in Paris on the subject, which have attracted much interest; and he has illustrated his views in musical compositions on an extensive scale, particularly a "Stabat Mater" which contains many novelties of tonal treatment.

NOTE B.—*Page* 167.

TIME IN MUSIC.

ALTHOUGH, as stated in the text, the feeling for regular periodic movement is undoubtedly a natural one, yet experience in practical music shows that it is far from being universal. Every musical teacher knows, to his cost, that to get the *time* of music properly attended to is usually the most difficult and uphill part of his task. Numbers of pupils, who are by no

means deficient in their idea of tune, appear almost hopelessly incapable of appreciating the metrical divisions, which have to be hammered into their intellects in the most mechanical way. And even when this may to a certain extent have been accomplished, it is by no means uncommon to find them fail in the ability to keep the movement *uniform* throughout a piece: they will either vary the rate, alternately quicker and slower, or, still worse, they will often "drop out" portions of a bar altogether, particularly where rests occur. And the fact of their being unconscious of these defects, after all the pains that has been taken to instruct them, shows that certain mental organisations are deficient in the natural appreciation of the rhythmical idea.

But we may go much higher and find, among well-educated and professional musicians, striking examples of the same natural deficiency. We must not, of course, look for such defects in written compositions, for without attention to time and rhythm these could not exist. But there is a very frequently recurring case that furnishes a test of the sense of these qualities, namely, *extempore playing.* In former times this was much cultivated, and many of the most esteemed composers, from Mozart to Mendelssohn, were in the habit, both privately and publicly, of exhibiting a most musician-like power and skill in this way. Now-a-days such exhibitions have become obsolete; but there are still occasions where extempore playing may be heard, chiefly on the organ. In Church services, for example, the opportunities for free performance are frequent, and are often taken advantage of for extempore exhibition; and the same may be said of many other public performances where organs are used.

Now it is a curious fact that, in by far the great majority of such cases, the performances one hears are *entirely destitute of time or rhythm.* They consist usually of harmonic combinations, sequences, and progressions, strung together in a totally amorphous way without an attempt at division or measure of any kind. This is one of the strangest phenomena in practical music. The players are often known as excellent musicians, who, in performing written music, would keep their time with the most immaculate precision; but when they have

to "make music" on the spur of the moment, they seem entirel to forget that this necessary element of it has any existence The only possible explanation is, that in these persons th *natural* sense of measured movement is wanting, and that thei attention to it in a general way is only matter of artificial edu cation. It is probable that they are, at the time, quite unawar of the defect, and would be greatly surprised if it were remarke that what they were playing had no claim to be called music i the modern sense of the word.

Pianoforte players have less frequent opportunities for extem pore display than organists; but in regard to them the sam remark will generally apply. Let any one listen attentively t a pianist, however great, who puts his or her fingers in an un premeditated way on the keys, and in nine cases out of ten i will at once be evident that no sense of time or rhythm can b present in the player's mind.

NOTE C.—*Page 202.*

THE ÆSTHETIC ORIGIN OF MUSICAL FORMS.

The following extracts from one of the most celebrated modern works on musical æsthetics, "Vom Musikalisch-Schönen," "On the Beautiful in Music," by Professor Hanslick of the University in Vienna, will further illustrate the opinions held by the most competent men on the æsthetic nature of the principles of musical structure. The references are to the fourth edition, Leipsic, 1874.

"There is no art the forms of which wear out so soon and so extensively as music. Modulations, cadences, progressions of intervals and harmonies, become so obsolete in fifty or even thirty years, that the composer of genius can no longer use them, but is compelled continually to invent new purely musical features. All that can justly be said of a mass of compositions which stood far above the average of their day, is that they once were beautiful. The fancy of the artist of genius discovers, among the infinite number of possible combinations, those that are the most choice and hidden, and works

them into novel musical forms, which, though they are purely the offspring of his own free will, seem connected, by an invisible thread, with the dictates of necessity."—*Page* 57.

"Let it be added, that musical beauty has nothing to do with mathematics. The hypothesis held by many critics as to the part played by mathematics in musical composition is remarkably vague. Not content with the facts that the vibrations of musical sounds, the magnitudes of intervals, the laws of consonance and dissonance, may be traced to mathematical relations, they are convinced that also the beauty of a piece of music is grounded on figures. They make the study of harmony and counterpoint a sort of *cabbala*, which is to teach composition by calculation.

"Although mathematical doctrine furnishes an indispensable key to the study of the physic of music, its part in a musical composition must not be unduly magnified. In a tone-poem, be it the finest or the worst, nothing is designed by calculation. Creations of the fancy are not to be likened to arithmetical sums. All monochord experiments, sound-figures, proportions of intervals, &c., areout of place here. The region of æsthetics begins where all these primary relations end. Mathematical science only prepares the elementary material for intellectual working, and lies hidden in the simplest relations; but musical ideas come to light without its aid. What converts music into poetical art and raises it out of the category of physical experiment, is something free and spiritual, and therefore incapable of being reduced to calculation. Mathematics has as much connexion with production in the musical art as it has with production in the other arts, and no more."—*Page* 66.

Few persons can seriously imagine that the beauties of musical composition can be produced by any mathematical process; but the remarks quoted are equally applicable to the more specious, plausible, and common delusion that the forms of musical structure generally are determined by physical laws: if they were so, musical beauty must be logically degraded into something producible by a process little better than mechanical manipulation.

"Man has not learnt the structure of music from nature. We may take it as firmly proved, that melody and harmony, our relations of intervals, our scales, our distinctions of tonality, and our equal temperament, have been slow and gradual creations of the human mind. Nature has given man, musically, nothing beyond the vocal organs and the desire to sing. She has, however, endowed him with a capacity gradually to erect a musical system on the foundation of simple natural phenomena, which remain as unchangeable supports for the various structures he has built upon them. We must guard against

the idea that our present system is necessarily founded in nature. The experience that people appear as naturally familiar with the musical relations as if they were born to them, does not by any means stamp the laws of music as natural laws: it is only the consequence of the infinite extent of musical culture."—*Pages* 115, 116.

NOTE D.—*Page* 209.

BEATS.

The phenomena of beats may be studied in the works of Helmholtz, Tyndall, or Sedley Taylor, or in an essay by the author of the present work, published in "Nature" for January 13th and 20th, 1876. A few details may here be added.

It will be gathered from the description in the text, that beats may arise (1) from two fundamental sounds that are nearly in unison: this kind may be called the *unison beat*; or (2) from two fundamental sounds which lie wider apart, but the overtones of which approach each other within beating distance: this kind may be called the *overtone beat*. The nature of the beats in each of these cases, and the rules governing their velocity, have been sufficiently illustrated by the examples given.

There is, however, a third kind of beat which was pointed out by the celebrated mathematician, Dr. Smith of Cambridge, in his learned work on Harmonics, published in 1749, and was afterwards further explained by Mr. De Morgan in the Cambridge Philosophical Transactions for 1858. It differs from the first mentioned kind of beat, in that it arises from the imperfection, not of *unisons*, but of wide-apart consonances, such as the third, fourth, fifth, sixth, and octave. It has been called the *beat of imperfect consonances*. It is well known practically to organ tuners, and is appreciable to any musical ear.

Taking the fifth as an example, let two notes forming this interval be sounded on an organ or any instrument of sustained tones. If they are perfectly in tune, the united sound will be smooth and even, or at least will only be subject to the "roughness" naturally inherent in the interval as mentioned in the

text. But if one of the notes be sharpened or flattened a little, a positive beat much more marked in character will be heard just as in the case of the imperfect unison, and will increase in rapidity as the note is made more and more out of tune.

There is some obscurity as to the real cause of this beat. It is explained by Smith and De Morgan to be a beat of the second order, depending, not like the unison beat on a cycle of differing periods, but on a cycle of differing cycles. Helmholtz gives a different explanation.

As this beat is of considerable practical use, it may be as well here to give the rule for its frequency, *i.e.*, for finding how many beats per second will result from the concord being any given quantity out of tune, and *vice versa.*

Let n represent the denominator of the fraction expressing, in the lowest terms, the true ratio of the concord (*e.g.*, for the fifth $\frac{3}{2}$, $n = 2$; for the minor sixth $\frac{6}{5}$, $n = 5$, and so on); then let q = the number of vibrations per second of the upper note, either in excess or deficiency of the number which would make the interval perfectly in tune. Also let β = the number of consonance beats per second; then, as a general formula, $\beta = n\,q$.

Applying this to the several consonances, we have the following results :—

For the unison or octave	$\beta = q$.
„ fifth	$\beta = 2\,q$.
„ fourth	$\beta = 3\,q$.
„ major third	$\beta = 4\,q$.
„ minor third	$\beta = 5\,q$.
„ major sixth	$\beta = 3\,q$.
„ minor sixth	$\beta = 5\,q$.

It will now be easy to understand why beats are capable of such great utility in a practical point of view, namely, as giving a means of measuring, with great ease and positive certainty, the most delicate shades of adjustment in the tuning of consonant intervals. To get, for example, an octave, a fifth, or a third perfectly in tune, the tuner has only to watch when the beats

will give him far more accuracy than he could possibly get by the ear alone. Whereas, if he desires to adopt any fixed temperament, he has only to calculate the velocity of beats corresponding to the minute error which should be given to each concord; and the required note may be tuned to its proper pitch with a precision and facility which would be impossible by the unaided ear.

The delicacy of this method would hardly be believed if it did not rest on proof beyond question. For example, in tuning, say, a fifth above middle *C*, the difference between 95 and 100 beats per minute would be appreciable by any one with a seconds watch in his hand; and yet this would correspond to a difference of only $\frac{1}{24}$ of a vibration per second, or in pitch less than $\frac{1}{500}$ of a semitone!

This use of beats has been long practised by organ tuners to some extent, but its capabilities, as amplified by the aid of calculation, are certainly not appreciated or used as they might be.

There is another practical use of beats, also very interesting, which has been alluded to on page 32 of this work, namely, that they furnish a means of ascertaining the positive number of vibrations per second corresponding to any musical note. This may be done either by the unison or by the consonance beat, as follows:—

For the unison beat:—Take two notes in unison on an organ, a harmonium, or other instrument of sustained sounds, and put one of them a little out of tune, so as to produce beats when they are sounded together. Let V and v represent the vibration-numbers of the upper and lower notes respectively. Then by means of a monochord it will be easy to determine the ratio $\frac{V}{v}$, which call m. Count the number of beats per second, which call β. Then, since $\beta = V - v$, we obtain the simple equation,

$$v = \frac{\beta}{m - 1}$$

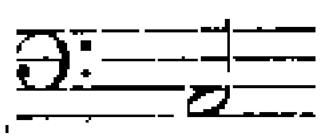
which gives the actual number of vibrations per second of the lower note of the two.

The method of deducing the vibration-number from the con-

sonance beat was pointed out by Dr. Smith; but as this method, so far as I know, is not to be found anywhere, except buried under the mass of ponderous learning contained in his work, I give it here in a simple algebraical form. If $\frac{m}{n}$ represent the true ratio of the interval, N the actual number of vibrations per second of the lower note, and M the same number for the upper one, the formula for the consonance beat becomes—

$$\beta = \left(m - n\frac{M}{N} \right) N; \text{ or } N = \frac{\beta}{m - n\frac{M}{N}}$$

Now, as m and n are both known for any given concord, if we can tell by any independent means the actual ratio of the notes $\frac{M}{N}$, we may, by simply counting the beats, calculate the actual number of vibrations N of the lower note. If the interval is too flat, β must be $+$; if too sharp, it must be $-$. The following example will show how this may be done:—

Let it be required to determine how many vibrations per second are given by the note  on an organ. Tune three perfect fifths upwards, and then a perfect major sixth downwards, thus—

which will give the C an octave above the original note. But, by the laws of harmony, we know that this octave will not be in tune; the upper C will be too sharp, the ratio being $\frac{81}{40}$ instead of $\frac{2}{1}$, as it ought to be. Hence $\frac{M}{N} = \frac{81}{40}$, and $\frac{m}{n} = \frac{2}{1}$. Count the beats made by this imperfect octave, and suppose them = 192 per minute, or 3·2 per second, then, as the interval is sharp—

$$N = \frac{-3 \cdot 2}{2 - \frac{81}{40}} = 128;$$

i.e., the note  is making 128 double vibrations per second.

This method has the advantage of dispensing with the use of the monochord, which was necessary in the former case.

NOTE E.—*Page* 152.

The Mean-Tone Temperament.

This was a system adopted, as stated in the text, for improving the intonation of church organs in the most useful keys, and a brief account of it may not be out of place.

According to the equal temperament, all keys are alike, and all equally out of tune; but it was thought, reasonably enough, that as only a limited number of keys are ordinarily in use, it would be worth while to improve these at the expense of the others which were so very seldom required. And this was ingeniously done in the following way:—

It was found by experience that the interval in regard to which the ear was most sensitive was the *major third*, the sharpness of which in the equal temperament renders all major triads so harsh and disagreeable. The fundamental principle therefore adopted on the alternative system was to make the *major thirds harmonically true* $= \frac{5}{4}$.

For the purpose of symmetrical construction, it next became necessary to abolish the difference between the major tone, $\frac{9}{8}$, and the minor tone, $\frac{10}{9}$, using for every tone in the scale a value $= \frac{\sqrt{5}}{2}$, intermediate between them. This gave to the system the name of the temperament by *mean tones*.

According to this, the diatonic scale of C major was tuned as follows, the numbers giving the logarithmic values, to five places,

of the intervals from the lower C, the corresponding true and equal values being added for comparison.

	Mean Tone Temperament.	True Harmony.	Equal Temperament.
C . .	30103	30103	30103
B . .	27165	27300	27594
A . .	22320	22185	22577
G . .	17474	17609	17560
F . .	12629	12494	12543
E . .	9691	9691	10034
D . .	4846	5115	5017
C . .	0	0	0

It will be seen by this that the interval of the fifth is a little more wrong than in the equal temperament, being about $\frac{1}{20}$ of a semitone too flat; but this is quite imperceptible in the chord.

The *minor* third ($=7783$) is also $\frac{1}{20}$ of a semitone too flat, but as the ear is very much less sensitive to this interval than to the major third, the error also passes unnoticed. Now, as it will be found that all the major triads, and all the minor triads, n the scale are exactly alike, the whole diatonic series is practically in perfect tune.

We have, then, to consider how this advantage may be extended to other keys, by the tuning of the black notes.

First, we will tune F♯ to form a perfect major third to D ($=14536$), and it will be found on trial that this will give a similar well-tuned series for the key of G.

Similarly, by tuning C♯ to a major third from A ($=1907$), and G♯ to a major third from E ($=19381$), we get similar scales for the keys of D and A respectively.

Proceeding now in the other direction, we tune B♭ as a major third below D ($=25258$), which will give us a similar well-tuned scale for the key of F; while by tuning E♭ as a major third below G ($=7784$), we get a similar scale for the key of B♭.

This completes the system of twelve notes to the octave, and

by it we get the six keys of C, G, D, A, F, and B♭ all perfectly in tune, which, considering the enormous extent to which they are practically used, is certainly an advantage.

Let us see now what we lose.

In the key of E♮ we have all the triads perfectly in tune, except that of the dominant. There is no D♯; we are obliged to use E♭ instead of it (= 7784 instead of 6753), about $\frac{2}{5}$ of a semitone too sharp, and this no doubt is a harsh effect, called technically a "wolf."

Similarly, in the key of E♭, all the chords are in tune except the subdominant, in which G♯ has to be used instead of A♭, giving a similar defect.

In some old organs (including the one at the Foundling Hospital, on which Handel used to play) two of the black keys were divided, giving the two additional notes which were wanted to correct these defects, and to bring the two keys named perfectly in tune. This arrangement has been long done away with in organs, but it is still retained in the concertina, which is tuned on the mean-tone temperament, and has fourteen notes in the octave.

In the keys of A♭, D♭, B♮, and G♭ worse errors occur, and these keys are very much out of tune.

On the whole, therefore, the case in regard to the mean-tone temperament, as applied to church organs, stands as follows:—

There are twelve keys in which music may be played.

In six of these, in which, perhaps, nine-tenths of the ordinary church music is written, or at least may be played without material disadvantage, the organ is in perfect tune.

In two keys, both to a less extent in use, there is one faulty and harsh chord.

In the remaining four keys, which never need be used at all, except in temporary modulations from simpler keys, the organ is badly out of tune.

This state of things was in the olden time considered sufficient to give a preference to the mean-tone system, the general harmonious effect being considered so great an advantage as to outweigh the disadvantage of an occasional harsh chord.

But *nous avons changé tout cela.* The organists insist on having the power of playing in the remote keys, and there is

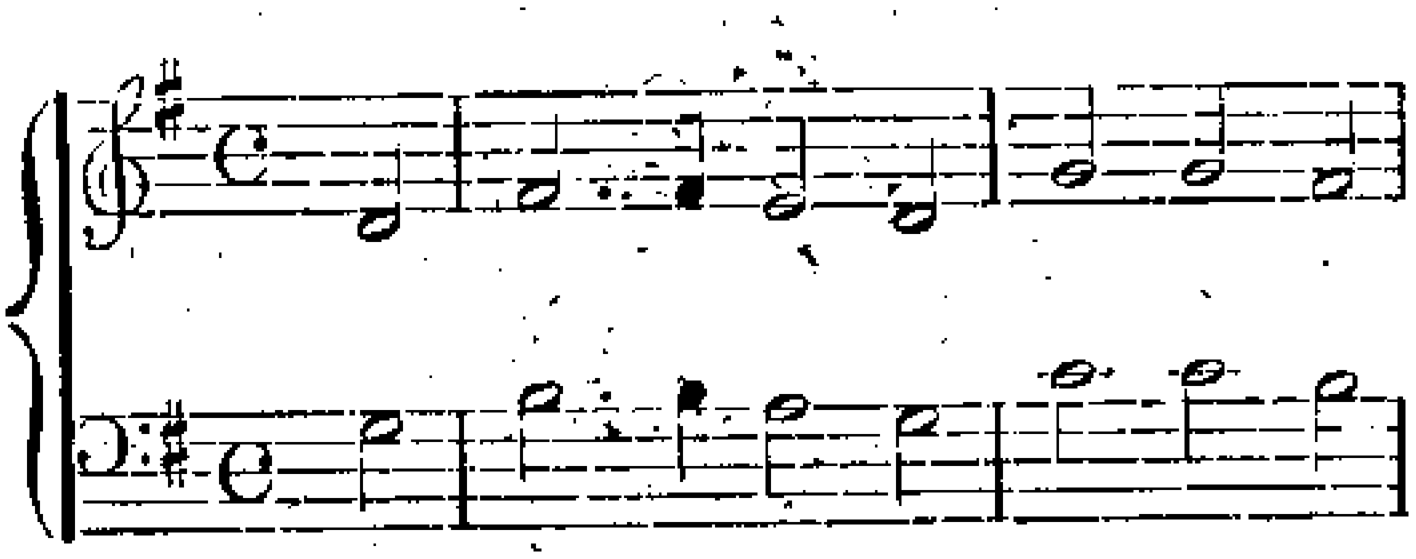
no help for it but to put the whole organ out of tune to please them. Whether the pleasure of the audience in listening to a closing voluntary in G♭ is so great as to compensate them for having heard every chord during the service with a harshly false third, is a matter that does not trouble the performer.

In organs for general use, with modern secular music, of course the whole conditions are changed, and the mean-tone system becomes inapplicable.

NOTE F.—*Page* 107.

SINGING IN FIFTHS.

Some eminent composer, in his autobiography or letters, mentions having heard singing in fifths by peasants in an Italian town. The author of this work heard the same in London at Christmas 1885. A strolling party were singing, in a street near the Marble Arch, the hymn, "When shepherds watched their flocks by night," to the well-known tune, No. 44, in Hymns Ancient and Modern. A man sang the melody in a baritone voice, in about the key of G, which a woman and three children accompanied in the alto a fifth above, thus—



The singing by both parties was fairly good, and the fifths were kept well in tune. Sometimes one party would stop for a few notes (as street singers often do), and would then take up the melody again quite correctly, showing that the interval of the fifth suggested itself quite naturally to them. It was curious that the woman and children should have chosen the fifth in preference to the octave, which would have been quite practicable for them, though it would probably have required more exertion.

A young lady who was at hand, a fair amateur singer, and much accustomed to good music, was asked if she had any remarks to make on the street singing. She thought it sounded somewhat strange, but did not appear to consider it offensive.

NOTE G.—*Pages* 116–119.

THE GREEK TRANSPOSING SCALES.

An important emendation in Greek musical history has recently appeared, too late to be incorporated in the text.

The author of this work, following the authority of Burney, Fétis, and Westphal, has described a change said to have been made in later times by the Greeks regarding their modes, which thereby became mere *transpositions* of one of the ancient octave-forms, the others having fallen out of use.

Burney and Fétis had both expressed themselves unfavourably about this alleged change, and the author cordially joined in this opinion, believing it a retrograde and effeminate step, unworthy of the musical spirit of the Greek nation.

Some months ago a musician of eminence, now residing in Sydney, Australia, Mr. Neville G. Barnett, wrote to the author stating that he had been led to question the accuracy of this generally received element of Greek history; but as his investigations had not been published, the author was unable to make reference to them.

But in the third volume of a work of great learning and research that has just appeared,[1] the new historian confirms Mr. Barnett's view. He shows that the fifteen modes of Aristoxenus and Alypius were by no means simple transpositions of one and the same scale, but were of very varied character, and really retained all the original octave-forms.

If this emendation is correct it wipes out a serious blot in Greek history; and it certainly is corroborated by the circumstance, that no effect corresponding to any such change was manifested on the music of succeeding periods.

[1] "A History of Music," by John Frederick Rowbotham. In three vols. London: Trübner & Co. 1887.

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